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Nesting and Brooding Characteristics of Sharp-Tailed Grouse (Pedioecetes Phasianellus Jamesi Lincoln) in Southwestern North Dakota

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NESTING AND BROODING CHARACTERISTICS OF SHARP-TAILED GROUSE (*PEDIOECETES PHASIANELLUS JAMESI* LINCOLN) IN SOUTHWESTERN NORTH DAKOTA

by

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This thesis submitted by Carter Drew Christenson in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota is hereby approved by the Faculty Advisory Committee under whom the work has been done.

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Date December 10, 1970

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[1]A contribution in part of Federal Aid in Wildlife Restoration, Pittman-Robertson Project W-67-R-10 and 11, Job 13, North Dakota.

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ABSTRACT

A study of the nesting and brood habitat preferences of sharp-tailed grouse (Pedioecetes phasianellus jamesi Lincoln) was conducted in southwestern North Dakota during the reproductive seasons of 1969 and 1970. Radio telemetry was used to monitor the spring and summer activities of seventeen sharp-tail hens. Eight brooding hens were semi-continuously radio-tracked for movement and cover selection. A quantitative and qualitative analysis of seventeen nests and eight renests was made to determine the preferred nesting cover and the effects of intensive grazing upon it. Nests were established either in non-use areas or in areas of light to moderate grazing. These included both taller patch vegetation of draws and shorter uniform vegetation of open fields; greater hatching success occurred in the uniform areas. Important nest site species included crested wheat-grass (Agropyron cristatum), buckbrush (Symphoricarpos occidentalis), and sweet clover (Melilotus officinalis). Non-use grasslands, edges of heavily grazed pastures, and brushy draws were utilized extensively by broods.

INTRODUCTION

This study was conducted to investigate and define the habitat requirements of the sharp-tailed grouse (Pedioecetes phasianellus jamesi Lincoln) during the reproductive season. A determination of specific requirements might indicate possible improvements for the land management systems currently in use in southwestern North Dakota, where approximately 1.1 million acres are administered by the U.S. Forest Service and Bureau of Land Management under the multiple-use concept. Therefore, new concepts, indicated by this and other studies, might be applied to this vast area resulting in a management system suitable for both livestock and grouse.

The study was conducted under a cooperative agreement between the North Dakota State Game and Fish Department, the U.S. Forest Service, and the University of North Dakota. The main objectives were (1) to determine the dispersal of sharp-tail hens from dancing grounds to nesting sites, (2) to determine the quality and quantity of selected nesting cover, (3) to determine the influence of intensive grazing management (rotation grazing) on grouse habitat and populations, and (4) to determine the home range, daily movement patterns, and cover preferences of sharp-tail broods.

DESCRIPTION OF THE STUDY AREA

Location

The study area is in northern Billings County, North Dakota west of Fairfield and northeast of Gorham (Figure 1). It is located in T. 143N., R.99W., Sec. 16-21 and 28-33; T. 143N., R. 100W., Sec. 13, 24, 25, and 36, and is bordered on the west by the Badlands and on the east by U.S. Highway 85. More than half of the 10,240 acres of the area is under U.S. Forest Service control.

Native vegetation

The native grasslands of southwestern North Dakota commonly include dominant species from both the mixed and true prairie associations. Uplands are commonly occupied by neddle-and-thread (Stipa comata), green needle (S. viridula), western wheatgrass (Agropyron smithii), sedges (Carex spp.), little bluestem (Andropogon scoparius), junegrass (Koeleria cristata), blue grama (Bouteloua gracilis), side-oats grama (B. curtipendula), fringed sage (Artemisia frigida), (Hanson and Whitman, 1938); the principal introduced species is crested wheatgrass (A. cristatum).

Trees and brush are mainly confined to draws or are found in close proximity to them. Woody species of importance include buckbrush, (Symphoricarpos occidentalis), buffalo

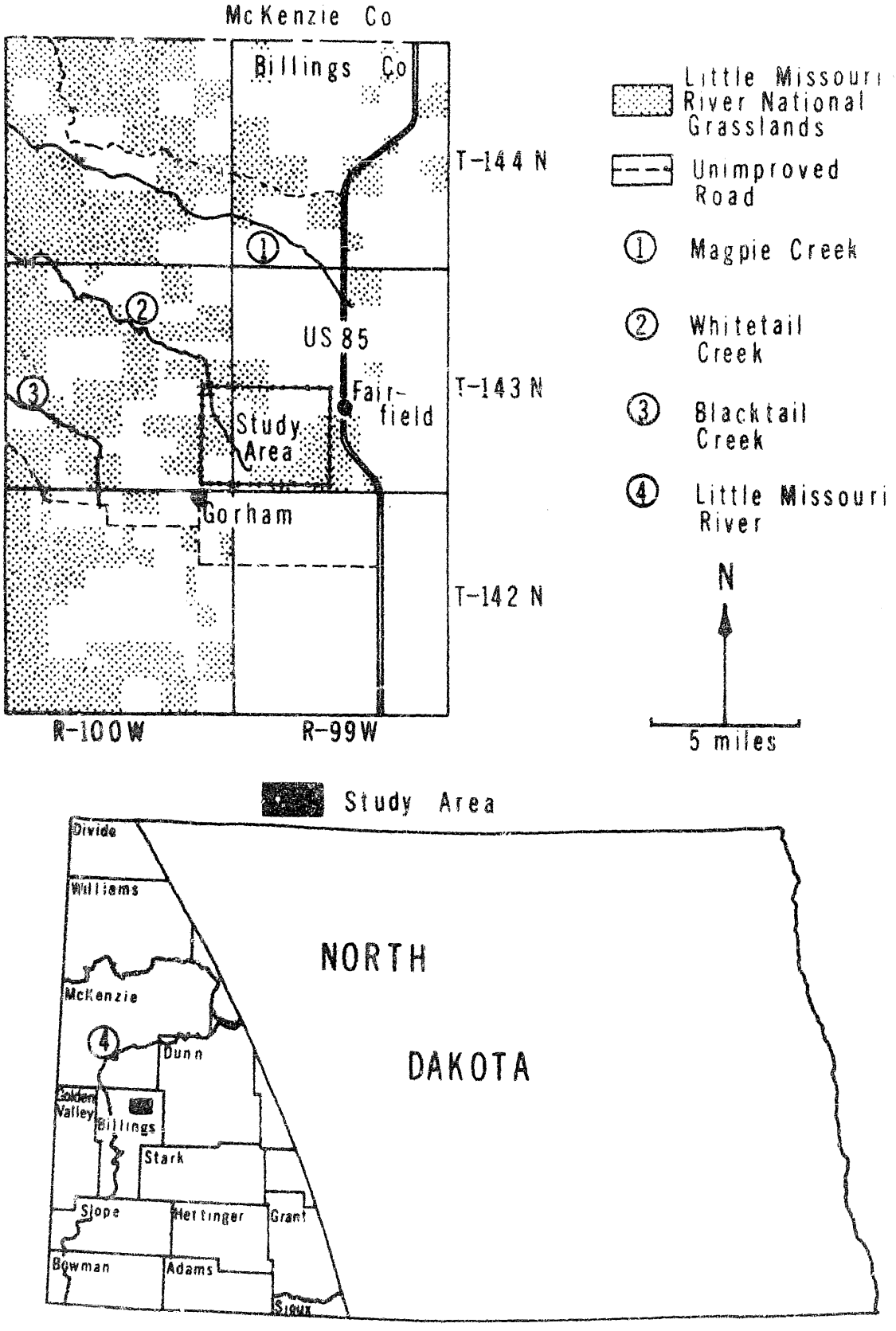

Fig. 1.--Location map of Gorham Study Area, North Dakota 1969-1970

TABLE 1.--Land-use on 23,680 Acres on and Surrounding Gorham Study Area, Summer, 1968 (Bernhoft, 1969)

Cover type	Cultivated		Cover type	Non-cultivated	
	No. of acres	Per cent of total		No. of acres	Per cent of total
Wheat	1,940.8	8.2	Native pasture	13,841.7	58.5
Oats	288.1	1.2	Native hay	882.6	3.7
Barley	79.2	0.3	Idle areas	190.4	0.8
Rye	26.4	0.1	Trees	52.6	0.2
Flax	5.4	tr	Road ditches	286.0	1.2
Millet	9.1	tr	Fence rows	59.2	0.3
Corn	73.9	0.3	Farm steads	95.1	0.4
Alfalfa	594.1	2.5	Roads	105.4	0.4
Mixed hay	1,756.5	7.4	Soil bank	110.5	0.5
Crested wheat grass	1,683.8	7.1	Field borders	9.0	tr
Mixed pasture	249.2	1.1	Marsh	16.3	0.1
Summer fallow	1,284.6	5.4	Open water	40.1	0.2
TOTAL	7,991.1	33.7		15,688.9	66.3

LITERATURE REVIEW

Grouse habitat and range management

In South Dakota good prairie grouse habitat consisted of native pasture less than 50 per cent utilized, unmowed hayland, trees, shrubs, and weeds; poor habitat included cultivated land, heavily utilized native grass, and mowed hayland. Areas with less than 50 per cent good habitat had retrogressing densities, those with 50 - 60 per cent had increasing densities, however, those with more than 70 per cent did not have correspondingly higher densities (Janson, 1953; Podoll, 1955 and 1957; Frary, 1958; West, 1959). Janson (1953) recommended that sharp-tail habitat in South Dakota should consist of 74 per cent grassland, one-third overgrazed or mowed, 14 per cent small grains, 3 per cent row crops, and 1.5 per cent trees or brush.

In the Lake States, sharp-tails require more woody cover, nevertheless, they are still dependent upon open areas. Ideal prairie grouse habitat in this area should include 6 per cent open grassland for dancing, feeding, and loafing; 50 per cent mixed woodland and grassland for roosting, nesting, and feeding; and 44 per cent woodland with small grassy openings for winter feeding and roosting, for resting, brood-rearing, and escape cover (Ammann, 1957).

Grange (1948) defined the minimum unit of optimal sharp-tail range in Wisconsin as 2,000 acres. Uhlig and Hamor (1966) suggested that the minimum practical size of a sharp-tail habitat under ideal conditions would range from one square mile in forested to four square miles in grassland areas; five times as much area was required in poorer habitats.

The importance of brushy draws, shrubs, and woody vegetation has been well documented (Johnson, 1934; Marshall and Jensen, 1937; Hamerstrom and Hamerstrom, 1951b; Yocom, 1952; Janson, 1956), however, overbrowsing curtails woody vegetation (McKenzie, 1963). On the other hand, it has been demonstrated that the replacement of grassland in the Lake States by woody cover is more detrimental to grouse than overgrazing (Leopold, 1933; Hamerstrom and Hamerstrom, 1951a). Therefore, management entails maintenance of open areas by controlled burning, herbicides, and mechanical disturbances (Doll, 1955; Newman, 1959; Ammann, 1963; Mattson 1963).

Population densities of sharp-tailed grouse are directly related to the quality of the vegetation of grassland habitats. However, maintenance of normal plant cover or climax grassland is impossible under excessive grazing and trampling (Weaver, 1954). Correlations between the amount of grazing and erosion, and floral and faunal changes have been described by Smith (1940). Henderson (1964) found that heavily grazed native grasslands where annual utilization was 50 - 100 per cent were unsuitable as grouse habitat; the greatest grouse populations were found where grazing

light or moderate, less than 50 per cent. The adverse effect of increased grazing pressures and agricultural practices on sharp-tail populations have been well documented (Schrader and Erickson, 1944 in Minnesota; Buss and Dziedzic, 1955 in Washington; Janson, 1956 and Henderson, 1964 in South Dakota; Evans, 1961 in Alberta; Hamerstrom and Hamerstrom, 1961 in the Dakotas and Nebraska; Brown, 1963 and 1966a in Montana).

Uhlig and Hamor (1966) stated:

> Proper range management that assures peak forage production and the maintenance of the best forage producing native grass species will provide adequate nesting, rearing, and roosting cover.

Mathison (1963) postulated that good range management is also good grouse management. Therefore, a very important criterion for sharp-tailed grouse management is the regulation of grazing to insure proper range management (Hart, Lee, and Low, 1950; Hamerstrom and Hamerstrom, 1961; Henderson, 1964).

Telemetry

Radio telemetry has been employed in the study of numerous wildlife species but was first applied to an upland game bird species, the ruffed grouse (Bonasa umbellus), by Marshall and Kupa (1963). Other investigators have utilized radio telemetry with various species of prairie grouse (Brown, 1965; Slade, Cebula, and Robe , 1965; Cebula, 1966; McEwen and Brown, 1966; Robel, 1966; Viers, 1967; Bernhoft, 1969; Robel et al., 1970). Telemetry also has been used in ring-necked pheasant studies by Kuck (1966). Bird activity has

been successfully interpreted by changes in transmitter signals, i.e., the subject is stationary, walking, flying, feeding, or dusting (Marshall, 1963; Brown, 1966b; Kuck, 1966).

Although sharp-tails and prairie chickens carring transmitters were thought to be more susceptible to predation, McEwen and Brown (1966) and Robel (1970) found them no more vulnerable than non-radio equipped birds. Studies of sharp-tails (Brown, 1965; Bernhoft, 1969), pheasants (Kuck, 1966), and prairie chickens (Cebula, 1966) also indicated that transmitters did not adversely affect normal activity. Kuck (1966) observed a copulation between a cock and a radio equipped hen pheasant.

Trapping techniques

Several trapping methods have been employed for capturing sharp-tail grouse during their reproductive season. The cannon-net described by Dill and Thornsberry (1950) was used to trap sharp-tails on dancing grounds (U.S. Fish and Wildlife Service, 1955; Peterle, 1956; Klett, 1957; Schwilling, 1960b, Kobriger, 1964; Brown, 1965; Bernhoft, 1969). The cannon-net has been mounted on the front of a vehicle to increase its mobility and effectiveness (Lacher and Lacher, 1964; Higby, 1969). Brown (1966b) and Bernhoft (1969) trapped sharp-tails on dancing ground with portable funnel traps.

Mist nets have been used to capture sharp-tails on dancing grounds (Evans, 1961), prairie chickens on booming

grounds (Silvy and Robel, 1968), instrumented brooding female blue grouse (Dendragapus obscurus) (Schladweiler and Mussehl, 1969), and female sharp-tails and broods (Artmann, 1969). Incubating sharp-tails have been taken with spring operated bow-net traps (Bernhoft, 1969) and with long handled hoop nets (Schwilling, 1960b; Brown, 1966b; Bernhoft, 1969). Hoop nets have been used to capture brooding sharp-tails (Brown, 1965) and incubating pheasants (Kuck, 1966). Brown (1966b) and Cebula (1966) netted sharp-tails by pulling a large net over them at night. Evans (1961) trapped incubating and brooding hens with funnel-type traps. Robel et al. (1970) captured greater prairie chickens on booming grounds with mist, bow, and cannon nets and incubating hens with a long handled hoop net.

Hen dispersal

According to Hamerstrom (1939) females travel only short distances from breeding grounds to nesting sites. Uhlig and Hamor (1966) stated that sharp-tails usually nest within 1.0 mi. of dancing grounds and most authorities agree. Sharp-tail nests have been found within 0.5 mi. (Leopold, 1933), between 0.50 and 0.75 mi (Symington and Harper, 1957), within 0.75 mi. (Klett, 1957), and within 1.0 mi. (Kobriger, 1964) of the nearest dancing ground.

Nesting characteristics

Sharp-tail hens must utilize available cover for nesting, regardless of its quality, because they ordinarily

nest in the immediate vicinity of dancing grounds (Blus and Walker, 1966). In the Lake States most nests have been enclosed by heavy grass or concealed near or under logs, brush or at the base of small trees or bushed (Gross, 1930; Saunders, 1936; Baumgartner, 1939; Hamerstrom, 1939; Schrader and Erickson, 1944; Scott, 1947; Ammann, 1957; Bent, 1963; Evans, 1968).

In the Plains States Viehmeyer (1941) and Henderson (1964) considered that the most important basic needs of sharp-tailed grouse were nesting and rearing cover. A good nest site, according to Symington and Harper (1957), required an abundance of protective cover in the form of grasses and low shrubs and a readily available food supply. Schwilling (1960c) and Kobriger (1964) observed that prairie grouse nests were either in non-use or lightly grazed areas and that residual vegetation from the previous year's growth provided part of the required cover. Of 25 sharp-tail nests found by Bach (1943) none were on land extensively utilized by man, i.e., cultivated, closely mowed wild hay, or over grazed pasture. All were located on wild land partly used for pasture. Blus and Walker (1966) found that nests were usually in native prairie where little or no grazing had occurred; 7313 per cent were on range of excellent condition, 23.4 per cent on range of good condition, and 3.3 per cent on range of fair condition; none were on range which was undergoing severe or extreme grazing. Fifteen and five tenths per cent of the nests were located on the unused range which comprised less than 1 per cent of the total area. Although Hart et al.

(1952) and Blus and Walker (1966) found a few nests in stubble and alfalfa (Medicago sativa), the majority of nests begun in late April and early May were in patches of residual tall and medium height grasses, which persisted through the winter and spring (Janson, 1956), i.e., needlegrass (Stipa spp.) bluestem (Andropogon spp.), and wheatgrass (Agropyron spp.). Janson (1956) and Blus and Walker (1966) noted that nests were often located on north eastern exposures probably because of denser cover and a cooler and more moist microclimate. Sharp (1958) found that the body temperature of a ground nesting bird created a microclimate at the nest site which stimulated grass and forb growth at the periphery of the nest and hastened nest concealment.

The nesting season continues from late April to early July. Most nests were begun during the peak of the dancing season in late April or early May (Hamerstrom, 1939; Uhlig and Hamor 1966; Evans, 1968). Captive sharp-tails laid their first egg on May 1 or 2 and reached a peak during the period May 22 to June 11; after the first week of July very few eggs were laid (McEwen, Knapp, and Hilliard, 1969). However, observers generally agree that the peak of hatching in the wild occurs during the first three weeks of June (Baumgartner, 1939; Bach and Stuart, 1942; Blus and Walker, 1966; Brown, 1967). The average number of eggs per sharp-tail clutch was approximately 12 (Baumgartner, 1939; Hamerstrom, 1939; Bach and Stuart, 1942; Schrader and Erickson, 1944; Scott, 1947; Blus and Walker, 1966; Brown, 1967). High

fecudity has been found and fertility ranges up to 97 per cent (Brown, 1967). Baumgartner (1939) did not note a change in the clutch size from year to year and Brown (1966b) did not find a correlation between clutch size and the age of hens.

Hamerstrom (1939), Cartwright (1944), Ammann (1957), and Blus and Walker (1966) have agreed that reproductive success depends on initial nesting efforts because prairie grouse are not persistant renesters. However, according to Brown (1966b) instrumented sharp-tails renested persistantly; one hen renested twice in one summer. Successful renesting was measured by the spread of brood ages observed in August. Symington and Harper (1957) noted that the early destruction of first nests resulted in one or two additional attempts at renesting. Of 73 nests found by Blus and Walker (1966), 8.2 per cent were renests; these accounted for only 2.3 per cent of the chicks produced in 34 nests. Although a small sample was examined, it was observed that renests contain less eggs than initial nests. However, Brown (1966b) found no significant difference in the numbers of eggs in initial and renests. Sharp-tail nesting successes in North Dakota have been reported by Bach and Stuart (1942) and Bach (1943) as 68.0 per cent of 25 and 86.2 per cent of 29 nests, respectively. Ammann (1957) observed a hatching success of 44.0 per cent of 330 Michigan prairie grouse nests. In a recent study of prairie grouse in the Nebraska Sandhills, Blus and Walker (1966) reported 49.3 per cent hatch from 67 nests. They also noted

a correlation between hatching success and range condition. Hatching success on an over-grazed and intensively mowed area was 40.0 per cent of 35 nests and on an area which was less intensively utilized 61.3 per cent of 31 nests hatched; one nest was unaccounted for. Uhlig and Hamor (1966) stated that in average years approximately 50 per cent of the sharp-tail nests are successful.

The reproductive success may be related to the weather. Janson (1955), and Hamerstrom and Hamerstrom (1961) agreed that the greatest percentage of success occurred during relatively cool, wet summers; warm, dry weather was unfavorable to reproduction. During the drought periods of 1910-11, 1925-27, and 1934-37 there were disastrous reductions in sharp-tail nesting success (Janson, 1955). Zwickel (1958) suggested that weather affects blue grouse reproduction, i.e., years with warmer, wetter Mays enhanced the cover; dryer, warmer Junes favored broods. Young prairie grouse (Cartwright, 1944; Schwartz, 1945; Scott, 1947) and pheasant chicks (MacMullan and Eberhardt, 1953) are most vulnerable to weather extremes, particularly wet cold periods. A 50 per cent mortality occurs during the first 3 weeks of life in early sharp-tail broods (Brown, 1967). Four or at the most five, chicks from a clutch of 12 eggs can be expected to reach maturity (Symington and Harper, 1957).

Predation

The mechanism of staggering nesting attempts guarantees the survival of short lived species because it insures that

the total hatch would not be vulnerable to a general disaster at any one period of the reproductive season (Cartwright, 1944; Symington and Harper, 1957). However, Darrow (1945) indicated that the relative abundance of buffer species will determine the predatory pressure on ruffed grouse and their nests. Thus, predation must have been an important factor in an annual sharp-tail mortality of 60 to 70 per cent (Henderson, 1964). Brown (1966b) reported that coyote predation on nests and nesting hens was a major factor limiting total sharp-tail reproduction.

Brood Habitat

The influence of season, intensity, and type of grazing on the structure and composition of vegetation during the brood season have been discussed by Craddock and Forsling (1938) and Mueggler (1962). In early summer, sharp-tail broods utilized a variety of cover, generally within the immediate vicinity of the nest (Ammann, 1957; Klett, 1957; Brown, 1966b). Edminster (1954), Peterle (1954), and Ammann (1957) reported that broods moved to denser cover some distance from the nest site later in the summer, thus increasing brood range. However, Uhlig and Hamor (1966), Evans (1968), and Bernhoft (1969) have stated that summer brood territory rarely exceeds an area one-half mi. in diameter. Hamerstrom (1963) investigated 207 locations of 193 sharp-tail broods in the pine barrens of Wisconsin and found 80 per cent in open cover types, 14 per cent in edge habitats, and 5 per cent more than 50 yards into woodland. Grassland with shrubs

was determined to be the most important cover. Baumgartner (1939) found 17 broods in open uplands within 0.67 mi. of the nearest dancing ground with but one exception. Jackson (1963) studied 44 sharp-tail broods and found 67 per cent of them in ungrazed and 33 per cent in grazed areas; 29 were in native grasses, 16 in exotic grasses and 10 in annual weeds. Natural woody cover along draws offered shelter and shade to broods in one summer (Henderson, 1964).

Kobriger (1964) observed that broods roosted at night in upland sandhills on the Valentine Refuge in Nebraska and spent days in the mowed wetland meadows. During the day any available shade, including trees, windrows, unmowed areas, and other patches of vegetation, were utilized. He also reported that broods abandoned wetland meadows following mowing. Brown (1966b) noted the concentration of broods following the early dessication of grasses and forbs in a year of low rainfall; occasional grouping of broods or broods and non-brooding hens were also observed. The daily sequence of hen-brood activity consisted of night-roosting, morning feeding, day resting, and afternoon feeding; high temperatures, wind, and rain disrupted this normal cycle.

Vegetation analysis

There is a paucity of information concerning methods and techniques employed in evaluating nesting and brooding cover. Emlen (1956) developed a method to describe and compare avian habitats based on their measurable features, including characteristics of the vegetation, substrata, and

surrounding area. Vegetational height was considered the most important factor by Lack (1933) who employed this to differentiate various habitats. Gross cover requirements of ruffed grouse were described by Polderboer (1942) and Dorney (1959). Evans and Gilbert (1969) systematically assigned a numerical value to rate individual habitat components, including winter food, protective cover, nesting cover, area (grassland), shrub cover, topography, soil, and water. In aggregate these ratings indicated the potential value of a specific range. Seperately, they indicated those range components which required improvement. Jones (1960) recorded the physiognomic life-form types at prairie chicken flushing sites under three principal divisions: woody plants, half-shrubs, and herbs, with subdivisions according to height of vegetation.

Various types of equipment have been used in cover analysis, such as, photoelectric equipment to measure density (Allard, 1947; Sather, 1950) and photography for cover evaluation (Bump, 1950; Mosby, 1963). Wight (1939), Kobriger (1964), Jones (1968), and Bernhoft (1969) employed density boards to visually measure the cover of deer habitat, grouse breeding ground cover, grouse coverts, and grouse nesting cover, respectively. Jenkins (1961) and Watson (1964) described techniques to evaluate specific cover types for Hungarian partridge (Perdix perdix perdix) and red grouse (Lagopus lagopus scoticus), respectively. Both use visibility of models of the species being studied as the criterion for rating the particular cover.

Bue, Blankenship, and Marshall (1955) evaluated waterfowl nesting cover using height-density class rating. As grazing increased, there was a concomitant reduction in rating and total number of nests. Bernhoft (1969) adapted the clipped hoop method of range analysis to evaluate nesting cover for sharp-tails. The degree of use guide described by Dyksterhuis (1944) was used by Schwilling (1960a) to determine preferred nesting cover of prairie grouse. This was based on livestock utilization in the vicinity of nest sites.

METHODS AND MATERIALS

Trapping and marking

Field work continued from April 15 through August 20, 1969 and from April 1 through August 26, 1970. Work began with inventory of dancing grounds to determine areas of female concentrations and activity in order to place traps in the most advantageous locations for capturing birds. The areas were prebaited with corn and wheat before single three-funnel (6' X 6' X 3') walk-in traps were set up on dancing grounds 1, 4, and 6 in 1969. Ground 4 was also trapped with a double, Miller-improved cannon-net assembly (75' X 50') in 1969. In 1970 a double, Dill recoilless cannon-net assembly (60' X 40') was used on grounds 2, 4, and 5. All trapped birds were weighed, sexed, and banded with numbered, aluminum, open-end type leg bands and color-coded celluloid leg bands to designate toe dancing ground from which the birds were trapped.

A long handled hoop net and a spring operated bow-net trap were used to recapture incubating hens for battery replacement and weighing. One incubating hen was taken from her nest by hand and one brooding hen was recaptured with a bumper mounted mobile cannon-net (50' X 40'). The long handled hoop net was also utilized to capture young brood members during the summer.

Telemetry

Sharp-tail hens were equipped with radio transmitters according to the technique of Brander (1968) and released. The battery leads were connected, soldered and the entire battery component was taped and then waterproofed with dental acrylic, liquid-tape (G. C. Electronics, Division of Hydrometals, Inc., Rockford, Illinois). Hens were located with a portable receiver and hand-directional antenna. Telemetry equipment (Sidney L. Markusen, Electronics Specialties, Esko, Minnesota) was similar to that of Bernhoft (1969) with two exceptions. A second portable receiver was employed as a back-up unit and only the 28 inch, portable, hand-directional antenna was used; the stationary yagi antenna was abandoned.

Dispersal of hens

Radio equipped hens were released near the dancing ground trap sites. They were monitored for dispersal and nest selection. Dispersal distances were measured on a straight line from the dancing ground to the nest sites.

Vegetation at nest sites

Vegetation at 22 nesting sites was sampled using the clipped hoop method of range analysis (U.S. Department of Agriculture, Forest Service, 1969). Three nest sites were not clipped as the cover had changed drastically by being mowed, plowed, or destroyed by hail. Herbage within two hoops, each subtending a 0.96 square foot area, was clipped at opposite edges of the nest. This was identified, sacked,

and air dried for subsequent weight determination. Clippings of two 1969 nests were made in early August following seasonal growth of the vegetation. Nine of twelve 1969 nests were clipped during the spring of 1970 on or near the dates the hens occupied the sites the previous year. All 1970 nests were clipped as early as possible in the reproductive season after hatching, predation, or desertion. Production was measured in pounds per acre and percentage of each plant species. The former was computed by multiplying the weight in grams of a species found within the two hoops by 50.

As soon as nests were located, a 2 X 1 foot cover board, horizontally marked with alternating one inch white and black strips was temporarily placed at two adjacent edges of each nest to visually analyze the cover. This board was removed after the observations were made. Height and density of vegetation was determined by the following two procedures: (1) observations of the number of strips completely covered by vegetation were made giving a 100 per cent density-height factor; and (2) estimations of the maximum height of the vegetation were made from the per cent of the board obscured by the taller vegetation above the 100 per cent density-height factor (Bernhofc 1969).

Paced line transects were run in the vicinity of seven nest sites in pastured areas. Vegetative and soil conditions were rated according to a five division scale of excellent, good, fair, poor and very poor vegetative and soil trends were also noted (U.S. Department of Agriculture, Forest Service 1969).

Brood movement and cover selection

For each brood seen during the summer, the location, adjacent land-use, vegetative cover height and density, and species composition were recorded. In addition to these occasional sightings, intensive observations were made of broods of radio equipped hens. Daily movements and activities of these broods were determined with up to three individual contacts per day. Occasional days with dawn-to-dusk checking at 15 minute intervals supplemented the data collected by the normal daily checks. Instrumented hens and broods were located visually without flushing to determine vegetation preferences. Brood survival was determined by periodic counts on those days when broods were accidentally flushed.

RESULTS

Trapping and marking

Sharp-tails were trapped on the five active dancing grounds within the study area (Table 2). Of 62 sharp-tails captured during the study, 36 were males and 26 were females. Weight data for these birds are summarized in Table 3. In 1969, ten males were cannon-netted on ground 4, one was caught on ground 1 with a walk-in trap, and four were caught in a walk-in on ground 6. The male from ground 1 and one from ground 6 had been banded on their respective grounds the previous spring. Two young of the year males were hoop netted during the summer. In 1970, 19 males were cannon-netted on three grounds, four on ground 2, two on ground 4, and thirteen on ground 5. One male from ground 4 had been banded the previous spring on the same ground and one male from ground 5 had been banded in the spring of 1967 on ground 5, then located one-half mile to the east. Of 17 females taken in 1969, 16 were cannon-netted on ground 4 and one young of the year female was hoop netted during the summer. In 1970 eight females were cannon-netted on three grounds, five on ground 2, one on ground 4, and two on ground 5. During the summer one young of the year female was hoop netted. A summary of all trapping is presented in Table 4.

TABLE 2.--Male Sharp-tailed Grouse Census, Gorham Study Area, North Dakota, Spring 1966-1970

Dancing Ground	Number of Males				
	1966[a]	1967[b]	1968	1969	1970
1	8	16	16	4	2
2	17	19	14	11	9
3	9	4	0	0	0
4	23	23	24	23	16
5	29	31	11	9	15
6	--	--	24	10	10
Total	86	93	89	57	52

[a]North Dakota State Game and Fish Department

[b]1967 and 1968 Data (Bernhoft, 1969)

TABLE 3.--Weights of Adult and Immature Sharp-tailed Grouse, Gorham Study Area, North Dakota, 1969-1970

Class	Number	Weight (grams)	Range	Mean
Adult males	34	31,033	794-1,077	913
Adult females	24	20,097	709-1,134	837
Immature males	2	369	156-213	184
Immature females	2	737	255-482	368

TABLE 4.--Sharp-tailed Grouse Trapping Methods and Success, Gorham Study Area, North Dakota, 1969-1970

Ground No.	Method	Trap Days 1969	Trap Days 1970	Males 1969	Males 1970	Females 1969	Females 1970	Total
1	Funnel Walk-in	14	-	1[c]	-	0	-	1
2	Cannon-net	-	6	-	4	-	5	9
4	Funnel Walk-in	14	-	0	-	0	-	0
	Cannon-net	2	1	10	2[d]	16	1	29
5	Cannon-net	-	6	-	13[e]	-	2	15
6	Funnel Walk-in	14	-	4	-	0	-	4
Nest[a]	Hoop net			-	-	5	2	7
	Nest trap			-	-	1	4	5
	Mobile Cannon-net			-	-	-	1	1
General[b]	Hoop net			2	-	1	1	4
Total		44	13	17	19	23	16	75

[a]All radioed hens recaptured for battery change

[b]Immature birds

[c]1 banded in 1968

[d]1 banded in 1969

[e]1 banded in 1967

Of six returns (4 males and 2 females) in the fall of 1969, five, including both females, were banded during the previous spring and one was banded during the spring of 1968. One return in 1970 had been banded during the previous spring. All birds were killed within one mile of their home grounds with the average distance being approximately one-half mile.

Telemetry

Of 18 females trapped, radio-equipped, and released, eleven were taken on ground 4, five on ground 2, and two on ground 5. Table 5 presents the weight changes of six radio-equipped hens between the spring capture and the mid-incubation recapture dates. One young female brood member was captured, radio-equipped, and released during the summer but contact was lost the next day.

The effective range of transmitters was 0.75 mi., however, under ideal conditions, the range was up to 2.0 mi. Topography, density of vegetation, and location and activity of birds affected normal transmission and reception.

Battery life varied throughout the study. Of 31 transmitters operational for 12 to 110 days, averaging 53 days, only four were lost unexpectedly. These were probably due to battery failures.

Dispersal of hens

Eighteen radio-equipped females were monitored from dancing grounds to nesting areas to provide dispersal

TABLE 5.--Comparison of Initial Spring and Mid-incubation Weights[a] of Six Sharp-tailed Grouse Hens, Gorham Study Area, North Dakota 1969-1970

	Spring		Mid-incubation		
No.	Date	Weight	Date	Weight	Weight Loss[b]
1-69	4-23-69	907	6-11-69	822	85
2-69	4-23-69	822	6-4-69	765	57
4-69	4-23-69	765	6-10-69	680	85
7-69	4-23-69	879	6-11-69	822	57
2-70	5-4-70	879	6-17-70	737	142
10[i]-70	4-30-70	794	6-17-70	709	85

[a]In grams

[b]Mean weight loss 85

[i]Intermittent signal channel

information (Figure 2 and Table 6). Table 6 also presents the results of 17 initial nests and eight renests. In 1969 ten hens were monitored for 925 days and in 1970 eight hens were monitored for 714 days. Radio monitoring data and the final disposition of each hen is summarized in Table 7.

Channel 1-69, instrumented April 23, was monitored for 121 days; the hen's recorded activity centered around a shallow draw containing buckbrush 0.9 mi. west of dancing ground 4. A nest, containing eleven eggs, was discovered in this area on June 9. This nest was destroyed June 20 and the hen moved to a draw 1.5 mi. southwest of the dancing ground and remained in this vicinity for the rest of the summer.

Channel 2-69, instrumented April 23, was tracked for 156 days. This hen remained close to a draw bordering a crested wheatgrass field in which her nest of thirteen eggs was discovered May 13, 0.8 mi. southwest of dancing ground 4. Eight of the final total of fifteen eggs hatched June 13.

On April 30, channel 3-69, was equipped with a radio and was followed for 56 days. Until May 19 the hen remained in a draw 1.4 mi. northeast of dancing ground 4. An additional dancing ground later discovered at this location could have been attended by this female. On May 20, the hen moved 0.6 mi. further northeast to a deep draw in which the nest was discovered May 30. It was located in a buckbrush patch and contained seven eggs. On June 14, the hen was missing

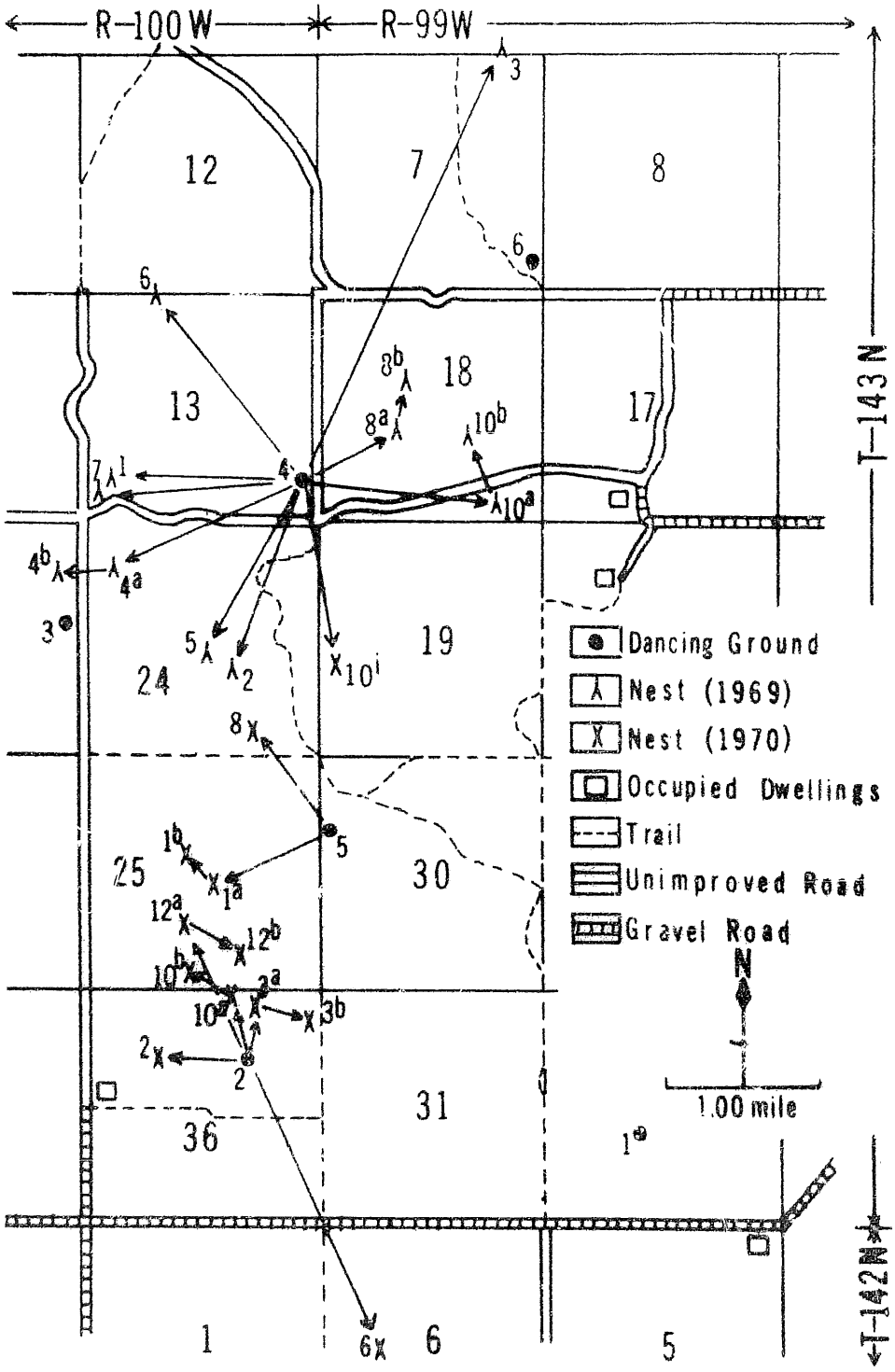

Fig. 2.--Hen Dispersal from Dancing Grounds, Gorham Study Area, North Dakota, 1969-1970

TABLE 6.--Sharp-tailed Grouse Hen Dispersal and Nesting, Gorham Study Area, North Dakota, 1969-1970

Channel	Dispersal (miles)		Direction from dancing ground	Nesting results
	Maximum	Nest[d]		
1-69	1.0	0.9	W	Egg predation
2-69	0.8	0.8	SSW	Hatched
3-69	2.0	2.0	NNE	Hen predation
4[a]-69	0.9	0.9	WSW	Egg predation
4[b]-69	1.5	1.2	WSW	Hen and egg predation
5-69	0.9	0.8	SW	Hatched
6-69	1.1	1.1	NW	Hatched
7-69	0.9	0.9	W	Egg predation
8[a]-69	0.8	0.4	ENE	Egg predation
8[b]-69	0.8	0.7	NE	Hatched
10[a]-69	1.1	0.8	E	Egg predation
10[b]-69	1.1	0.7	ENE	Hatched
1[a]-70	0.5	0.5	WSW	Nest predation
1[b]-70	0.6	0.6	NNE	Hatched
2-70	0.5	0.3	W	Hatched
3[a]-70	0.9	0.2	N	Nest predation
3[b]-70	0.4	0.3	ENE	Hen lost (mammalian predation?)
6-70	1.7	1.7	SSW	Hatched
8-70	0.5	0.5	NW	Hatched
10[a]-70	0.4	0.3	NNW	Nest predation
10[c]-70	0.4	0.4	NW	Abandoned
10[b]-70	0.4	0.4	NW	Abandoned

TABLE 6.--Continued

Channel	Dispersal (miles)		Direction from dancing ground	Nesting results
	Maximum	Nest[d]		
12[a]-70	0.8	0.5	NW	Nest predation
12[b]-70	0.3	0.3	NNW	Hatched
10[i]-70	0.8	0.8	S	Hatched

[a]Initial nest

[b]Renest

[c]Nest bowl

[d]Mean distance 0.8

[i]Intermittent signal channel

TABLE 7.--Telemetric Study and Final Disposition of 18 Sharp-tailed Grouse Hens, Gorham Study Area, North Dakota, 1969-1970

Channel No.	Date Instrumented		Monitoring Discontinued	Total Days Monitored	Battery Life		Disposition
	Initial	Second			Initial	Second	
1-69	4-23	6-11	8-20	121	50	71	Study terminated
2-69	4-23	6-3	9-20	152	42	110	Hen collected
3-69	4-23	-	7-18	80	80	-	Avian predation
4-69	4-23	6-10	6-22	61	49	12	Mammalian predation
5-69	4-23	-	6-12	44	44	-	Signal lost
6-69	4-23	6-2	7-23	93	41	52	Signal lost
7-69	4-23	6-11	8-20	121	50	71	Study terminated
8-69	5-1	-	8-8	100	100	-	Signal lost
9-69	4-23	-	4-30	7	7	-	Signal lost
10-69	5-1	7-6	9-20	146	79	67	Hen collected
Subtotal				925			

TABLE 7.--Continued

Channel No.	Date Instrumented Initial	Date Instrumented Second	Date Monitoring Discontinued	Total Days Monitored	Battery Life Initial	Battery Life Second	Disposition
1-70	5-16	7-9	8-11	87	54	33	Avian predation
2-70	5-5	6-17	8-25	112	43	69	Study terminated
3-70	5-5	-	7-8	64	64	-	Signal lost (Mammalian predation?)
6-70	5-5	6-16	7-8	64	42	22	Avian predation
8-70	5-12	6-24	8-8	88	43	45	Mammalian predation
10-70	5-5	7-9	8-13	100	65	35	Mammalian predation
12-70	5-5	7-21	8-25	112	77	35	Study terminated
10[i]-70	4-30	6-17	7-25	87	49	38	Mammalian predation
Subtotal				714			
Grand total				1639			

[i]Intermittent signal channel

from the nest and the radio signal could not be heard. Several feathers were found at the nest site indicating possible predation on the hen although the nest was intact. On July 18 the remains of the hen were found on a high butte 0.7 mi. west of the nest site. It was assumed that an avian predator killed this particular sharp-tail.

Channel 4-69 was released April 23 and followed for 61 days. This hen's nest was located on a crested wheatgrass hilltop 0.9 mi. west southwest of dancing ground 4. Nest predation occurred May 20, and the hen moved west across a road to a sweet clover field. The hen renested in this field, 1.2 mi. west southwest of the dancing ground. The renest, found June 9, and the hen were preyed upon June 22; the bird remains were found approximately 150 yards west of the nest.

Channel 5-69, initiated April 30, was monitored for 44 days. This hen occupied the same draw and crested wheatgrass field as channel 2. Channel 5's nest was discovered in the crested wheatgrass field 0.8 mi. southwest of dancing ground 4 on May 18 and contained nine eggs. The completed clutch contained 11 eggs of which only eight hatched on June 11. The entire brood was killed apparently by cold (chill factor 14F.) during a prolonged and unsuccessful early morning attempt to capture the hen to replace an inoperative transmitter.

Channel 6-69 was followed for 93 days after release on April 23. The hen located in a draw 1.1 mi. northwest of

dancing ground 4 and her nest of 13 eggs was found under a buffalo berry bush on the slope of the draw May 12. The entire clutch hatched on June 6, coincidental with a thunderstorm with large hail which resulted in the loss of the entire brood. The hen remained in the area for the entire summer.

Instrumented April 23, channel 7-69 was tracked for 121 days. The hen located along a creek 0.9 mi. west of dancing ground 4 and nested on the side of a draw in buckbrush 50 yards from channel 1-69's nest. The nest containing eight eggs was found on June 5. Predation destroyed the clutch of ten eggs on June 23. The hen remained in the draw and pasture area 1.0 mi. northeast of the nest site and 0.75 mi. northwest of the dancing ground. This area was also used by channel 6-69 and the two birds were occasionally located together.

Channel 8-69, released May 1, was followed for 100 days. She located in a pasture containing shallow draws and ranged up to 0.8 mi. east of dancing ground 4. Her nest containing three eggs was located May 12 in the bottom of a draw containing smooth brome (Bromus inermis), 0.4 mi. northeast of the dancing ground. Nest predation destroyed 11 eggs on June 6. The bird renested 0.7 mi. northeast of the dancing ground in the same shallow draw. This nest, which was located June 23, was under a single large sweet clover plant in a smooth brome-alfalfa field. A total of nine eggs hatched July 17.

Channel 9-69 was lost the day following release, April 24. She was recannon-netted on dancing ground 4 April 30, but was subsequently lost again with no data collected.

Channel 10-69 was released May 1 and followed for 146 days. The hen located in the same pasture and shallow draw area as channel 8-69 and ranged up to 1.1 mi. east of dancing ground 4. Her nest of 11 eggs was found May 12 in the edge of dense buckbrush in a shallow draw 0.8 mi. east of the dancing ground. The total clutch of 13 eggs was destroyed by a predator June 6. Renesting took place and a completed nest of nine eggs was located June 23. This was in sparce buckbrush on a flat adjacent to the draw where her first nest was located and was 0.7 mi. east northeast of the dancing ground. On July 20, six of eleven eggs hatched.

Channel 1-70 was instrumented May 16 and followed for 87 days. She centered her activities around an aspen (Populus tremuloides) draw 0.5 mi. west of dancing ground 5. Her nest of 11 eggs was found May 29 under a buffalo berry bush at the edge of this draw. Nest predation occurred June 4. A second nest containing nine eggs was discovered June 18 on a hillside between two side draws 100 yards from the first nest. Seven of the completed clutch of 10 eggs hatched July 15.

Channel 2-70, released May 5, was mointored for 112 days. Two days following release a copulation was observed between this hen and a male on dancing ground 2. She

located in an alfalfa field west across a draw from the dancing ground. Thirteen eggs were found in her nest in the alfalfa May 27, 12 of the final clutch of 14 eggs hatched June 25.

Channel 3-70, released May 5, was tracked for 64 days. Her initial nest of 11 eggs was found May 29 in quackgrass (Agropyron repens) and annual weeds north across a draw from dancing ground 2. Nest predation occurred on June 2. A renesting attempt produced 14 eggs in a nest located 0.3 mi. east northeast of the dancing ground in quackgrass and buckbrush. On July 9 the hen was missing from the nest and never located again. Mammalian predation may have taken place in the heavy nesting cover because numerous feathers were found near the nest site.

Channel 6-70 was monitored for 64 days after release May 5. On May 29, a nest containing 15 eggs was found 1.7 mi. south southeast of dancing ground 2 in a non-use area on Cropland Adjustment Program land. The entire clutch hatched June 22.

Channel 8-70, instrumented May 12, was followed for 88 days. A nest of 13 eggs was found May 29, 0.5 mi. northwest of dancing ground 5 in the crested wheatgrass used previously by channel 2-69 and 5-69. All eggs hatched June 22.

Channel 10-70 was released May 5 and followed for 100 days. Her first nest of six eggs, located 0.3 mi. north northwest of dancing ground 2, was found June 8 and destroyed by a predator June 14. On June 22 she was flushed from a scratched out depression that appeared to be the beginning

of a nest bowl 0.4 mi. northwest of the dancing ground. Abandonment of the nest bowl apparently occurred because five eggs were found in a new nest 20 yards from the depression on June 29. This nest of 8 eggs was abandoned on July 9 after the hen was reinstrumented prematurely during the first few days of incubation to replace a non-functional transmitter. The hen remained in the draw and pasture 0.2 to 0.7 mi. northwest of the dancing ground for the remainder of the summer.

Channel 12-70, released May 4, was traced for 112 days. The initial nest of 9 eggs was found 0.5 mi. northwest of dancing ground 2 on May 24. A clutch of 16 eggs had been laid before nest predation occurred June 14. The product of renesting was a nest of 7 eggs located June 28 in a crested wheatgrass area 0.3 mi. north northwest of the dancing ground. The entire clutch hatched on July 23 during a period of numerous thundershowers which killed the entire brood. The hen remained in the vicinity of the dancing ground the entire summer.

Channel 10^{i}-70 was released April 30 and monitored for 87 days. On May 31 a nest with a clutch of 15 eggs was found at the edge of a wooded draw 0.8 mi. south of dancing ground 4. Fourteen eggs hatched June 24.

Vegetation at nest sites

Species composition of vegetation at nine 1969 sites and thirteen 1970 nest sites is presented in Tables 8-14, respectively. The cover in proximity to three 1969 nests

TABLE 8.--Species Composition and Amount of Vegetation at Channel 4-69 and 10-69 Nest Sites, Gorham Study Area, North Dakota. Vegetation Sampled by Clipped Hoop Method, Fall 1969 and Spring 1970

Species	Channel	4[a]		4[a]		10[b]		10[b]	
	Date	8-10-69		5-6-70		8-10-69		6-20-70	
		lbs./acre	%	lbs./acre	%	lbs./acre	%	lbs./acre	%
Agropyron cristatum		1372.0	68.0	740.5	39.3				
Agropyron smithii						122.0	6.1	170.0	4.3
Bromus japonicus								58.0	1.5
Buchloe dactyloides		11.0	0.5						
Dantonia spp.						8.0	0.4		
Koeleria cristata		185.0	9.2	208.0	10.9	72.5	3.6		
Muhlenbergia cuspidata								28.0	0.7
Panicum capillare				112.0	5.9				
Poa pratensis						132.5	6.6		
Stipa comata		400.5	19.9	805.5	42.7				
Stipa viridula						125.5	6.3	180.0	4.5
Achillea lanulosa						29.5	1.5	190.0	4.8
Artemisia frigida		10.5	0.5			112.5	5.6		
Carex spp.						125.0	6.3	120.0	3.0
Crepis occidentalis						6.0	0.3		
Lotus americanus						27.5	1.4		
Mamillaria spp.		34.5	1.7						
Melilotus officinalis						73.5	3.7		
Rosa arkansana						19.5	1.0	120.0	3.0

TABLE 8.--Continued

Species	Channel Date	4[a] 8-10-69		4[a] 5-6-70		10[b] 8-10-69		10[b] 6-20-70	
		lbs./acre	%	lbs./acre	%	lbs./acre	%	lbs./acre	%
Symphoricarpos occidentalis						1117.0	55.9	2673.0	67.2
Taroxicum officianale						8.0	0.4		
Tragapogon dubius								174.0	4.4
Unclassified forbs		3.0	0.1	20.5	1.1	19.5	1.0	263.0	6.6
Total		2016.5	99.9	1884.5	99.9	1998.5	100.1	3976.0	100.0

[a]Initial nest

[b]Renest

TABLE 9.--Species Composition and Amount of Vegetation at Channel 1-69, 3-69 and 7-69 Nest Sites, Gorham Study Area, North Dakota. Vegetation Sampled by Clipped Hoop Method, Spring 1970

Species	Channel 1, Date 5-26-70		Channel 3, Date 5-26-70		Channel 7, Date 5-28-70	
	lbs./acre	%	lbs./acre	%	lbs./acre	%
Agropyron smithii	22.0	0.4	5.0	0.1	76.0	1.9
Koeleria cristata			65.0	1.3		
Poa pratensis	30.0	0.5			7.5	0.2
Stipa comata			13.5	0.3		
Stipa viridula	2680.0	46.9	1368.0	27.2	514.0	12.9
Achillea lanulosa					58.5	1.5
Artemisia ludoviciana			94.5	1.9	430.0	10.8
Carex spp.	10.0	0.2	124.0	2.5	33.0	0.8
Cirsium arvense	94.5	1.7				
Rosa woodsii			578.5	11.5		
Symphoricarpos occidentalis	2871.5	50.3	2775.5	55.2	2821.5	70.8
Unclassified forbs	5.0	0.1			45.0	1.1
Total	5713.0	100.1	5024.0	100.0	3985.5	100.0

TABLE 10.---Species Composition and Amount of Vegetation at Channel 6-69, 2-69, and 8[a]-69 Nest Sites, Gorham Study Area, North Dakota. Vegetation Sampled by Clipped Hoop Method, Spring 1970

Species	Channel 6[c] Date 5-6-70		Channel 2 Date 5-16-70		Channel 5 Date 5-16-70		Channel 8[a] Date 5-18-70	
	lbs./acre	%	lbs./acre	%	lbs./acre	%	lbs./acre	%
Agropyron cristatum			1814.5					
Agropyron smithii	787.5	48.9						
Bromus inermis							4980.5	100.0
Rosa woodsii	96.0	6.0						
Symphoricarpos occidentalis	725.5	45.0						
Unclassified forbs	2.5	0.1						
Total	1611.5	100.0	1814.5	100.0	2804.5	100.0	4980.5	100.0

[a]Initial nest

[c]Located at the base of a Sheperdia argentea bush

TABLE 11.--Species Composition and Amount of Vegetation at Channel 1[a]-70, 1[b]-70 and 2-70 Nest Sites, Gorham Study Area, North Dakota. Vegetation Sampled by Clipped Hoop Method, Summer 1970

Species	Channel 1[a c] Date 6-9 lbs./acre	%	Channel 1[b] Date 7-18 lbs./acre	%	Channel 2 Date 6-26 lbs./acre	%
Agropyron cristatum			2862.5	68.0		
Agropyron repens					1500.0	17.7
Agropyron smithii			186.0	4.4		
Boutelona gracilis					12.0	0.1
Poa palustris			68.0	1.6		
Stipa viridula	731.0	17.3	75.0	1.8		
Achillea lanulosa			221.0	5.3		
Artemisia ericardes	1.5	tr				
Artemisia frigida			157.0	3.7		
Artemisia ludoviciana	201.5	4.8				
Carex spp.	10.5	0.2				
Lactuca pulchella	5.5	0.1				
Medicago sativa					6716.0	79.4
Psoralea argophylla			631.5	15.0		
Rosa arkansana					218.0	2.6
Rosa woodsii	229.5	5.4				
Symphoricarpos occidentalis	3022.5	71.5				
Unclassified forbs	26.5	0.6	7.5	0.2	17.0	0.2
Total	4228.5	99.9	4208.5	100.0	8463.0	100.0

[a]Initial nest

[b]Renest

[c]Located at the base of Sheperdia argentea bush

TABLE 12.--Species Composition and Amount of Vegetation at Channel 3[a]-70, 3[b]-70, and 6-70 Nest Sites, Gorham Study Area, North Dakota. Vegetation Sampled by Clipped Hoop Method, Summer 1970

Channel	3[a]		3[b]		6	
Date	6-9		7-17		6-23	
Species	lbs./acre	%	lbs./acre	%	lbs./acre	%
Agropyron cristatum					2903.5	46.3
Agropyron repens	3073.5	60.6	2226.5	29.0		
Agropyron trachycaulum			1409.5	18.4	18.0	0.3
Avena fatua	6.0	0.1	25.0	0.3		
Bromus inermis					3179.0	50.7
Festuca octoflora					51.5	0.8
Muhlenbergia richardsonis			111.0	1.4	90.5	1.4
Annual weeds	1949.0	38.4				
Rosa woodsii			1293.5	16.9		
Symphoricarpos occidentalis			2498.0	32.5		
Unclassified forbs	41.5	0.8	110.5	1.4	23.0	0.4
Total	5070.0	99.9	7674.0	99.9	6265.5	99.9

[a]Initial nest

[b]Renest

TABLE 13.--Species Composition and Amount of Vegetation at Channel 10[a]-70, 10(nest bowl)-70, and 10[b]-70 Nest Sites, Gorham Study Area, North Dakota. Vegetation Sampled by Clipped Hoop Method, Summer 1970

Species	Channel	10[a]		10[c]		10[b]	
	Date	6-18		6-29		7-17	
		lbs./acre	%	lbs./acre	%	lbs./acre	%
Agropyron cristatum				411.5	12.0	332.5	9.9
Agropyron smithii		223.5	5.2	1125.5	33.0	699.5	20.9
Bromus japonicus		111.5	2.6				
Koeleria cristata				381.0	11.2	39.5	1.2
Poa arida		542.5	12.7				
Poa glaucifolia						1364.5	40.8
Poa pratensis				105.5	3.1		
Stipa viridula		3300.0	77.1	1019.5	29.9		
Annual weeds		29.0	0.7			519.5	15.5
Carex spp.		21.0	0.5				
Psoralea argophylla						130.5	3.9
Unclassified forbs		52.0	1.2	89.0	2.6	260.5	7.8
Vicia americana				283.0	8.3		
Total		4279.5	100.0	3415.0	100.1	3346.5	100.0

[a]Initial nest

[b]Renest

[c]Nest bowl

TABLE 14.--Species Composition and Amount of Vegetation at Channel 8-70, 12[a]-70, and 10[i]-70 Nest Sites, Gorham Study Area, North Dakota. Vegetation Sampled by Clipped Hoop Method, Summer 1970

Species	Channel 8, Date 6-22		Channel 12[a], Date 6-18		Channel 12[b], Date 7-27		Channel 10[i] [c], Date 6-26	
	lbs./acre	%	lbs./acre	%	lbs./acre	%	lbs./acre	%
Agropyron cristatum	6510.5	96.0	4941.5	95.2	4724.0	88.7		
Agropyron smithii			30.0	0.6			465.0	6.2
Koeleria cristata					160.5	3.0		
Panicum virgatum							25.5	0.3
Panicum wilcoxianum							6.5	0.1
Stipa comata					350.0	6.6		
Ambrosia psilostachya			27.0	0.5				
Artemisia frigida	3.5	0.1	139.0	2.7				
Artemisia ludoviciana							191.5	2.6
Carex spp.			8.5	0.2			2.0	tr
Psoralea argophylla			11.5	0.2				
Rosa arkansana	270.5	4.0						
Selaginella densa			25.5	0.5				
Symphoricarpas occidentalis							6806.5	90.7
Unclassified forbs			8.5	0.2	88.5	1.6	1.6	0.1
Total	6784.5	100.1	5191.5	100.1	5323.0	99.9	7501.0	100.0

[a]Initial nest

[b]Renest

[c]Located at the base of a Sheperdia argentea bush

[i]Intermittent signal channel

not analyzed consisted of a dense sweet clover field, a smooth brome-alfalfa field with a single sweet clover plant over the nest site, and the edge of a dense buckbrush patch in a draw.

The results of the visual analyses of all the nesting covers using a 1' X 2' cover board are shown in Table 15. Nineteen nests were located in pastures with light to moderate grazing, three in haylands, and three in non-use areas.

When the initial nests were found residual cover comprised from 10 to 90 per cent of all cover present. In renests residual cover varied from 0 to 60 per cent of all cover.

The vegetative condition of the vicinity of four of seven nests, as determined by paced line transects, were excellent; the other three were rated as good. In six of seven cases the vegetation trend was up; in all cases the soil trend was up.

Brood movement and cover selection

Cover characteristics and adjacent land-use data for 37 brood locations observed during the summers of 1969 and 1970 are presented in Table 16. These observations were made only in open areas serviced by roads or trails.

Eight radio equipped brooding hens were followed for periods of 4 to 61 days. Channel 2-69, which hatched eight of fifteen eggs from her nest in a crested wheatgrass field on June 13, remained within 50 yards of the nest during the following day. On June 15 the brood moved 0.3 mi. south

TABLE 15.--Characteristics of Cover at Sharp-tailed Grouse Nest Sites, Gorham Study Area, North Dakota, Based on 2 X 1 Foot Cover Board, 1969-1970

Site	Density in per cent	Height in inches	Dominants	Proximity to bushy draw (yards)	Per cent slope	Grazing
1-69	100 20	4 14	Symphoricarpos occidentalis Stipa viridula	0	10	Summer
2-69	100 40	3 12	Agropyron cristatum	150	0	Summer
3-69	100 15	4 15	Symphoricarpos occidentalis Stipa viridula	0	20	Summer
4[a]-69	100 40	3 12	Agropyron cristatum Stipa comata	150	5	Summer
4[b]-69	100 90	10 20	Melilotus officinalis	475	0	Hay-land
5-69	100 40	3 12	Agropyron cristatum	75	0	Summer
6-69	100 20	4 43	Sheperdia argentea Agrcpyron smithii	0	45	Summer
7-69	100 30	3 15	Symphoricarpos occidentalis Stipa viridula	0	20	Summer

TABLE 15.--Continued

Site	Density in per cent	Height in inches	Dominants	Proximity to bushy draw (yards)	Per cent slope	Grazing
8[a]-69	100	7	Bromus inermis	330	5	Winter[d]
	40	14				
8[b]-69	100	4	Melilotus officinalis	800	10	Hay-land
	80	24	Bromus inermis			
10[a]-69	100	4	Symphoricarpos occidentalis	0	20	Winter[d]
	70	15				
10[b]-69	100	3	Symphoricarpos occidentalis	100	5	Winter[d]
	30	14	Stipa viridula			
1[a]-70	100	3	Sheperdia argentea	0	25	Summer
	40	42	Symphoricarpos occidentalis			
1[b]-70	100	3	Agropyron cristatum	45	5	Summer
	50	18	Agropyron smithii			
2-70	100	6	Medicago sativa	350	15	Hay-land
	30	16	Agropyron repens			

TABLE 15.--Continued

Site	Density in per cent	Height in inches	Dominants	Proximity to bushy draw (yards)	Per cent slope	Grazing
3[a]-70	100	10	Agropyron repens	300	10	Non-use
	70	28	Annual weeds			
3[b]-70	100	9	Symphoricarpos occidentalis	130	0	Non-use
	70	28	Agropyron repens			
6-70	100	15	Bromus inermis	1760	15	Non-use
	80	30	Agropyron cristatum			
8-70	100	6	Agropyron cristatum	300	20	Summer
	60	25	Rosa arkansana			
10[a]-70	100	5	Stipa viridula	120	10	Summer
	40	12	Poa arida			
10[c]-70	100	5	Agropyron cristatum	120	5	Summer
	15	16	Stipa viridula			
10[b]-70	100	4	Agropyron cristatum	130	5	Summer
	25	21	Poa glaucifolia			

TABLE 15.--Continued

Site	Density in per cent	Height in inches	Dominants	Proximity to bushy draw (yards)	Per cent slope	Grazing
12[a]-70	100	2	Agropyron cristatum	220	5	Summer
	60	16	Agropyron smithii			
12[b]-70	100	4	Agropyron cristatum	210	20	Summer
	50	24	Stipa comata			
10[i]-70	100	4	Sheperdia argentea	0	15	Summer[d]
	60	70	Symphoricarpos occidentalis			

[a]Initial nest

[b]Renest

[c]Nest bowl

[d]Lightly grazed; portions also hayed

[i]Intermittent signal channel

TABLE 16.--Cover Characteristics and Adjacent Land-use at 37 Sharp-tailed Grouse Brood Locations, Gorham Study Area, Southwestern North Dakota, 1969-1970

Type	No. of broods	Cover height			Density			Species Composition			Adjacent Land-use						
		Under 12"	12-30"	Over 30"	Sparse	Medium	Heavy	Native	Exotic	Mixed	Summer grazed	Winter grazed	Winter grazed and hayed	Non-use with portions hayed	Non-use	Small grain	Summer follow
Grassland	20	9	10	1	3	12	5	12	2	6	13	2	2	1	2		
Brush	6		4	2		2	4	5	1		4				2		
Roadside	6	1	3	2		2	4	1	4	1	1			1	3	1	
Cultivated	2	1	1			1	1		2					2			
Hayland	3		1	2			3		3				2				1
Total	37	11	19	7	3	17	17	18	12	7	18	2	4	4	7	1	1

southwest in the crested wheatgrass field and remained there for two days. On June 17 they moved 0.4 mi. north northeast, past the nest site, into a cultivated field grown over with sweet clover and frenchweed (Thlaspi arvense). For the next three days the brood used this field and adjacent wooded and brushy draws. This brood moved 0.5 mi. south on June 21 to an area of sweet clover and brush within the crested wheatgrass field. After three days they moved 0.3 mi. southeast to an adjacent crested wheatgrass field on June 24. During the next three days a continuous rain apparently resulted in the loss of the brood. The hen moved 0.5 mi. further south remaining in a large pasture with deep draws for the remainder of the summer and was collected at this location on September 20 (Figure 3).

Channel 8-69, in her renesting success, hatched all nine eggs from a nest under a sweet clover bush in a smooth brome-alfalfa field July 17. This brood moved 200 yards north to the edge of an alfalfa field through July 19 and was found approximately 100 yards east of the nest site in an adjacent smooth brome-alfalfa field on July 20. The next day they had moved 0.4 mi. northwest to an alfalfa field where windrowing operations apparently resulted in the loss of the entire brood, because they were never seen with the hen again. The female spent the remainder of the summer in the draw area in which both the initial and renest had been located (Figure 4).

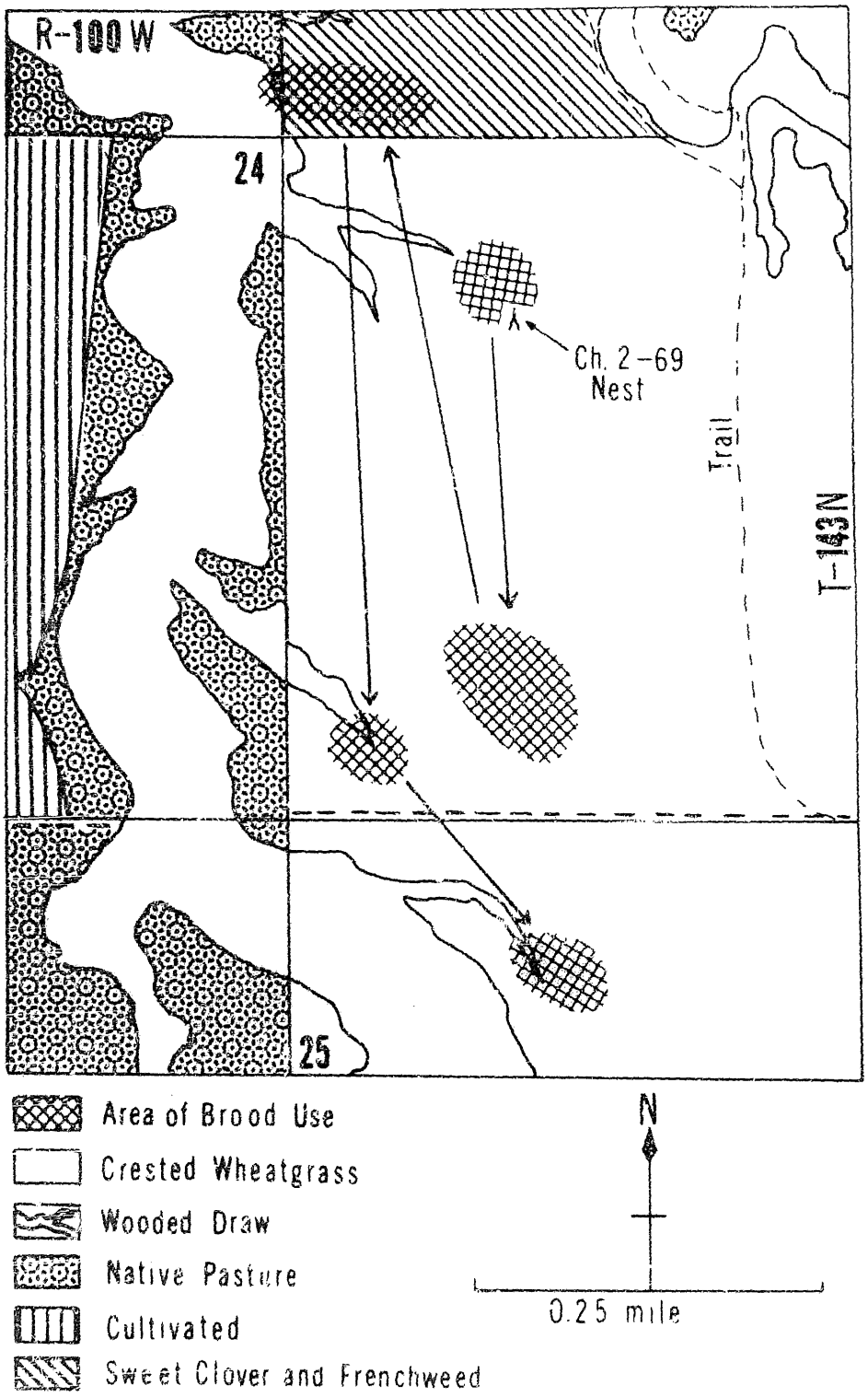

Fig. 3.--Channel 2-69 Brood Movement, Gorham Study Area North Dakota, 1969

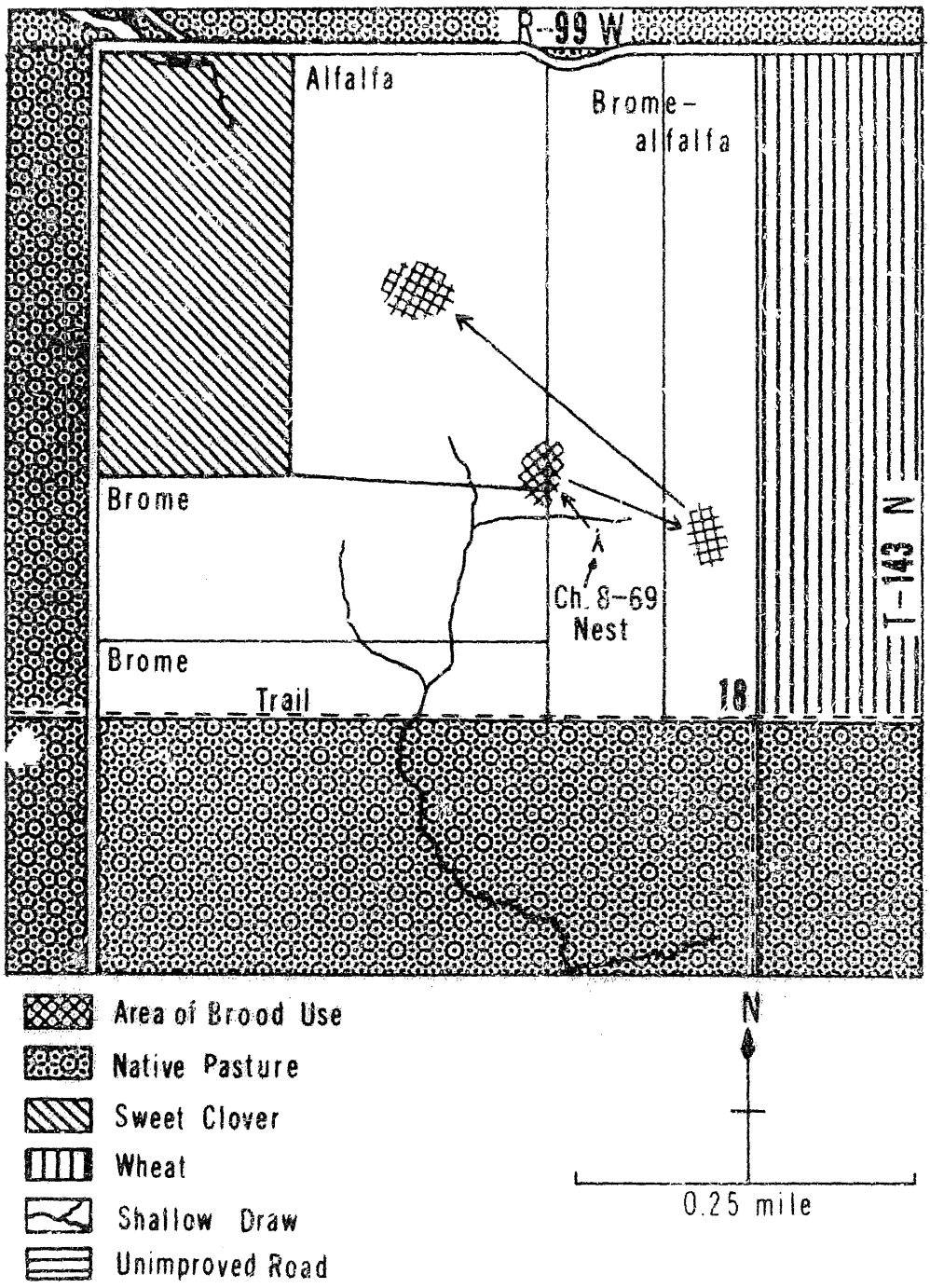

Fig. 4.--Channel 8-69 Brood Movement, Gorham Study Area, North Dakota, 1969

On July 20, channel 10-69 hatched six of eleven eggs from a nest located on a buckbrush flat. These were the result of an attempt to renest. She immediately moved the brood 100 yards north to a wheat (Triticum spp.) field and remained there until July 31. During the first four days of August the brood remained within 50 yards of the nest site in a pasture and used prairie thistle (Cirsium undulatum) and sweet clover for cover. The brood then moved 0.4 mi. southwest in this pasture, locating in crested wheatgrass, sweet clover, alfalfa, and white sage (Artemisia ludoviciana) patches from August 5-8. From August 9-18 they remained within 100 yards of the nest site and utilized prairie thistle and sweet clover cover. The hen and brood relocated in this pasture along a buckbrush draw 0.4 mi. south of the nest site on August 19-20. The study was terminated on August 20 and the hen was collected at the same location on September 20 (Figure 5).

Channel 1-70 hatched seven of ten eggs from her renest between two crested wheatgrass bunches July 15. After an initial move to a crested wheatgrass hilltop 0.4 mi. south of the nest site, this brood remained in the vicinities of the hilltop and the nest site through July 31 with occasional movements up to 0.5 mi. between these sites. August 1 and 2 were spent near a draw 0.5 mi. north of the nest site. The brood moved 0.7 mi. northeast to a native hayland on August 3 and remained there until the hen was taken by an avian predator on August 11. Throughout the first week this brood

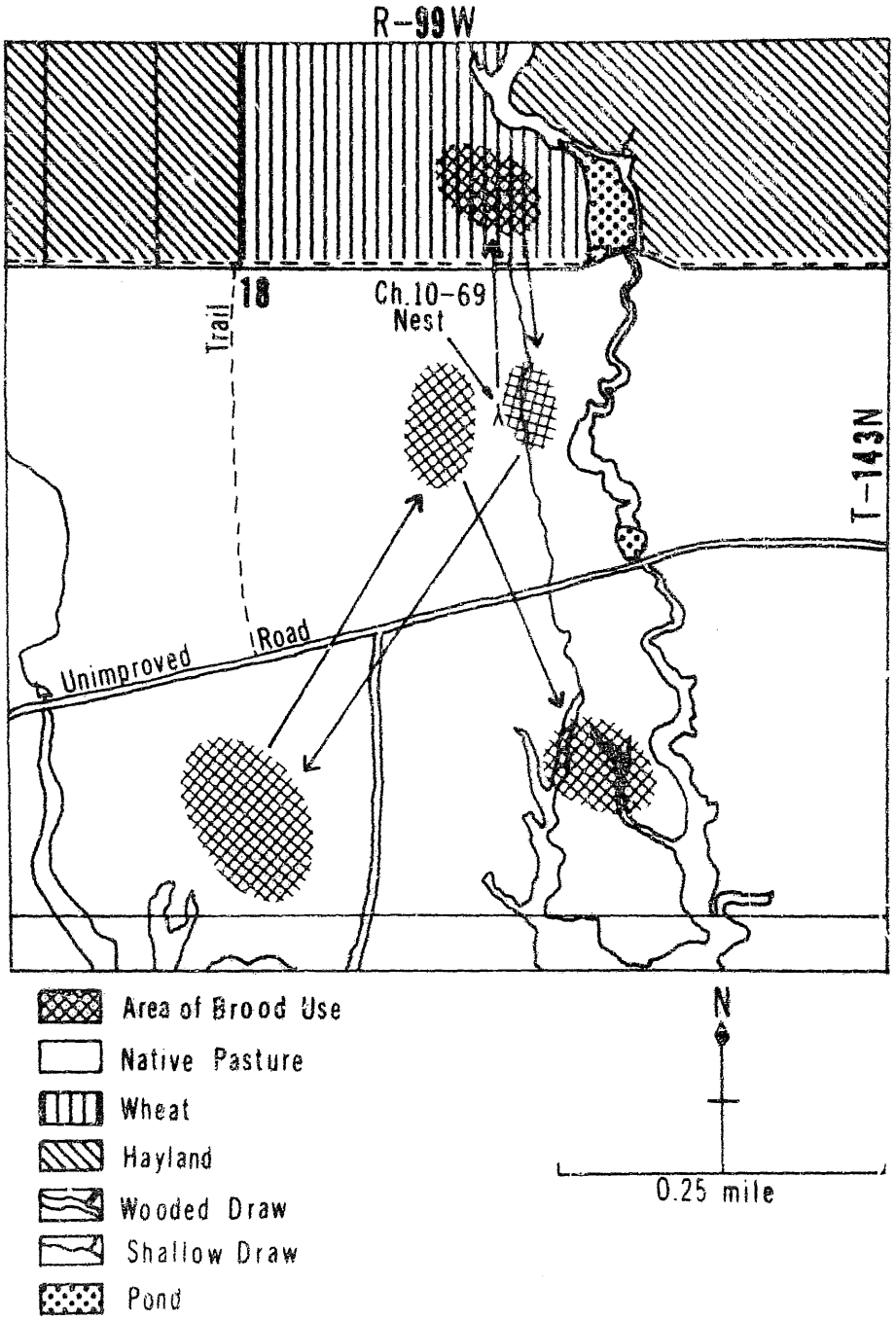

Fig. 5.--Channel 10-69 Brood Movement, Gorham Study Area, North Dakota, 1969

utilized crested wheatgrass exclusively for cover; during the second, third, and fourth weeks more dense vegetation (buckbrush and sweet clover) was used, particularly during the heat of the day. Throughout the period the brood roosted on upland sites (Figure 6).

Channel 2-70 hatched 13 of 15 eggs in an alfalfa field on June 25 and moved her brood 0.3 mi. north to an over-grazed pasture during the following week. Upland sites were for cover during this period. On July 3 the brood moved 0.8 mi. east to a wooded draw and remained there except for short daily movements until August 3. Contact with this brood was lost until August 12 when it was relocated in a wooded draw 1.5 mi. northeast of the original draw; its activities centered here until the termination of the study on August 25. From July 3 on, its activities were centered in wooded draws except for feeding during cool portions of the day and roosting at night (Figure 7).

On June 22 channel 6-70 hatched her entire clutch of 15 eggs. The next five days were spent along a grassy ridge 0.2 mi. north of the nest site. On July 28 the brood was moved 0.8 mi. north to a heavily grazed pasture and two days later 0.5 mi. west in this pasture where brushy vegetation was occasionally utilized for cover. From July 2 through July 7 the brood moved 1.2 mi. northeast into the Fairfield Common Pasture where the hen was lost to an avian predator July 8 (Figure 8).

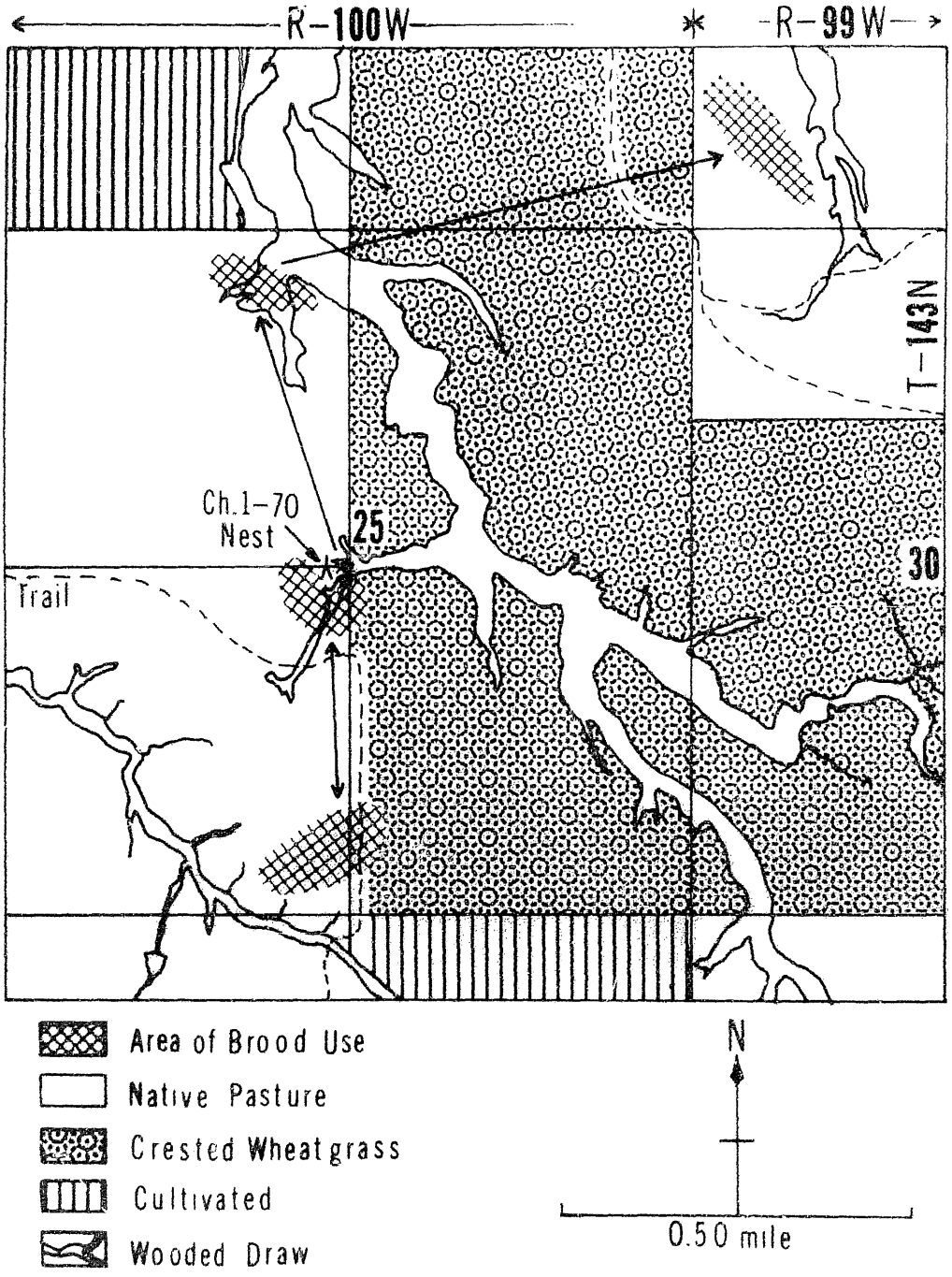

Fig. 6.--Channel 1-70 Brood Movement, Gorham Study Area, North Dakota, 1970

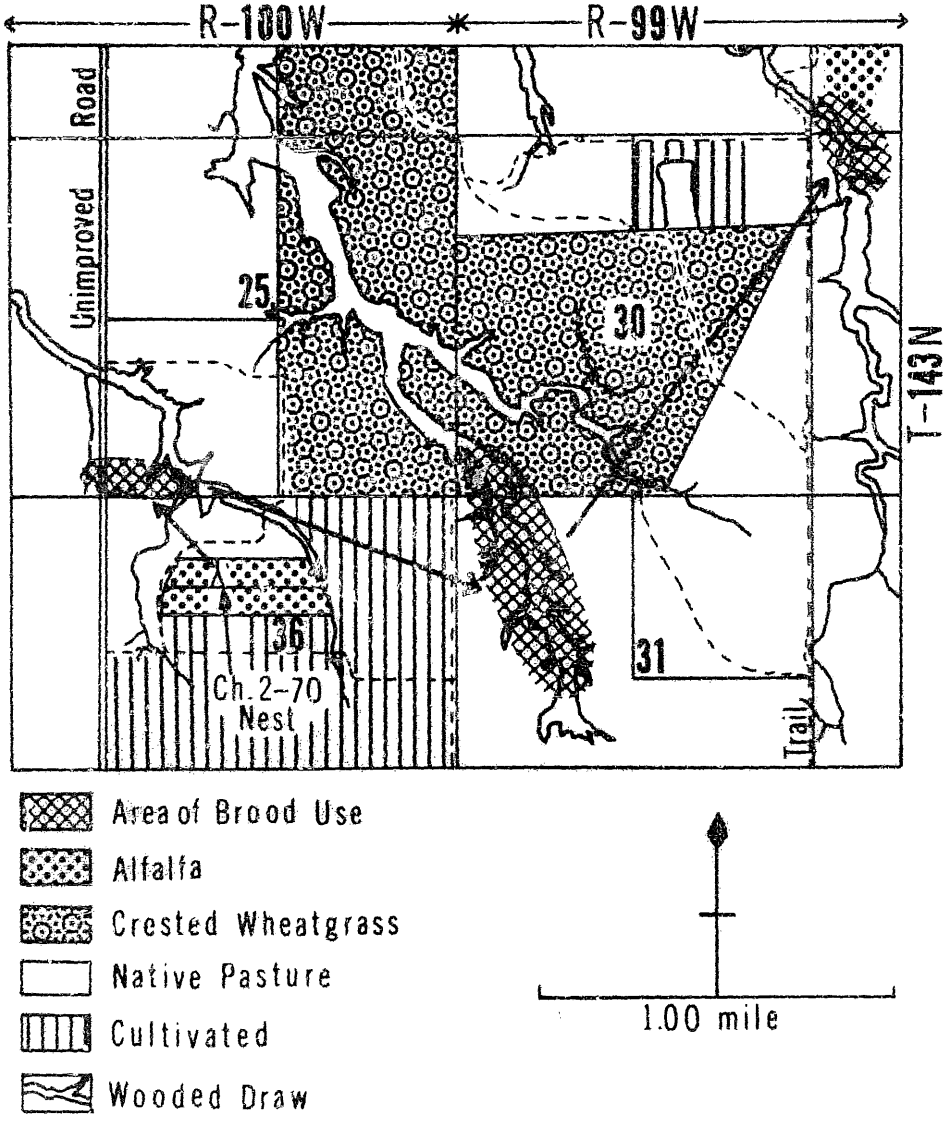

Fig. 7.--Channel 2-70 Brood Movement, Gorham Study Area, North Dakota, 1970

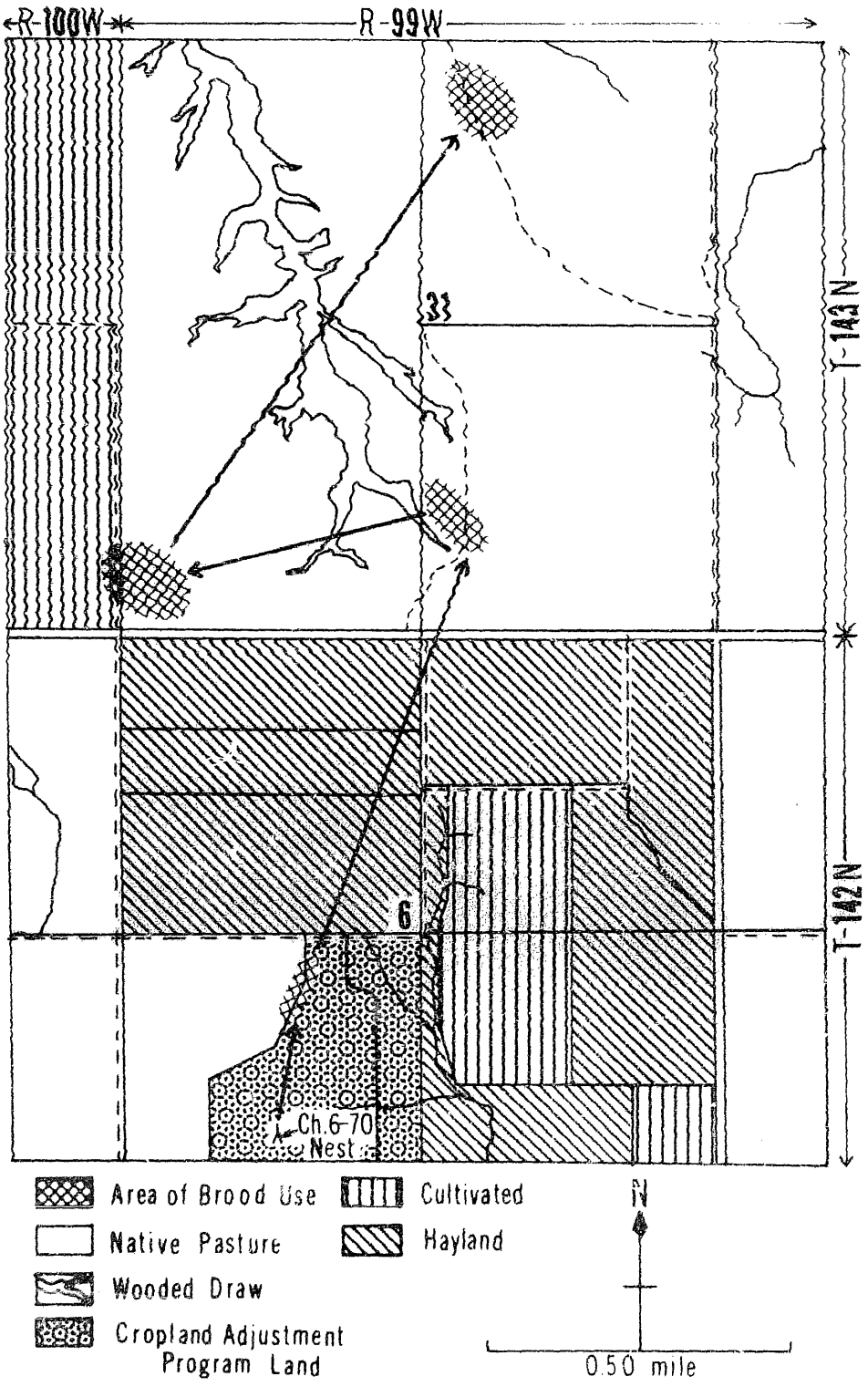

Fig. 8.--Channel 6-70 Brood Movement, Gorham Study Area, North Dakota, 1970

Channel 8-70 hatched 13 eggs on June 22. The following two days were spent in the crested wheatgrass within 0.2 mi. of the nest site. On June 25 the brood moved 0.3 mi. south to an adjacent crested wheatgrass field and the next day moved an additional 0.4 mi. south in the same field. On July 1 the brood traveled 2.8 mi. southwest to a native pasture where it remained through July 2. The following day the brood was located 0.7 mi. north in sweet clover cover adjacent to a wooded draw. Contact with the brood was lost until July 6 when the brood was relocated in a wooded draw only 0.4 mi. southwest of the nest site. The brood remained here until July 9 when it again moved into the adjacent crested wheatgrass field, south of the nest site. Following a week in this area, during which brushy vegetation was used only during hot weather, the brood traveled 1.0 mi. northeast on July 16 to a native hayland with considerable sweet clover. This cover was utilized until July 23 when the brood moved 1.5 mi. south to a wooded draw which was its center of activity until the hen was killed by a mammalian predator on August 8 (Figure 9).

Channel 10[i]-70 hatched 14 of 15 eggs from a nest located in a buffalo berry-buckbrush site. After one day spent in the vicinity of the adjacent draw the brood moved 0.6 mi. southwest to a crested wheatgrass field July 1 only to return to the native pasture July 3. The following week was spent here and at the edge of the adjacent Fairfield Common Pasture where sweet clover was the principal cover

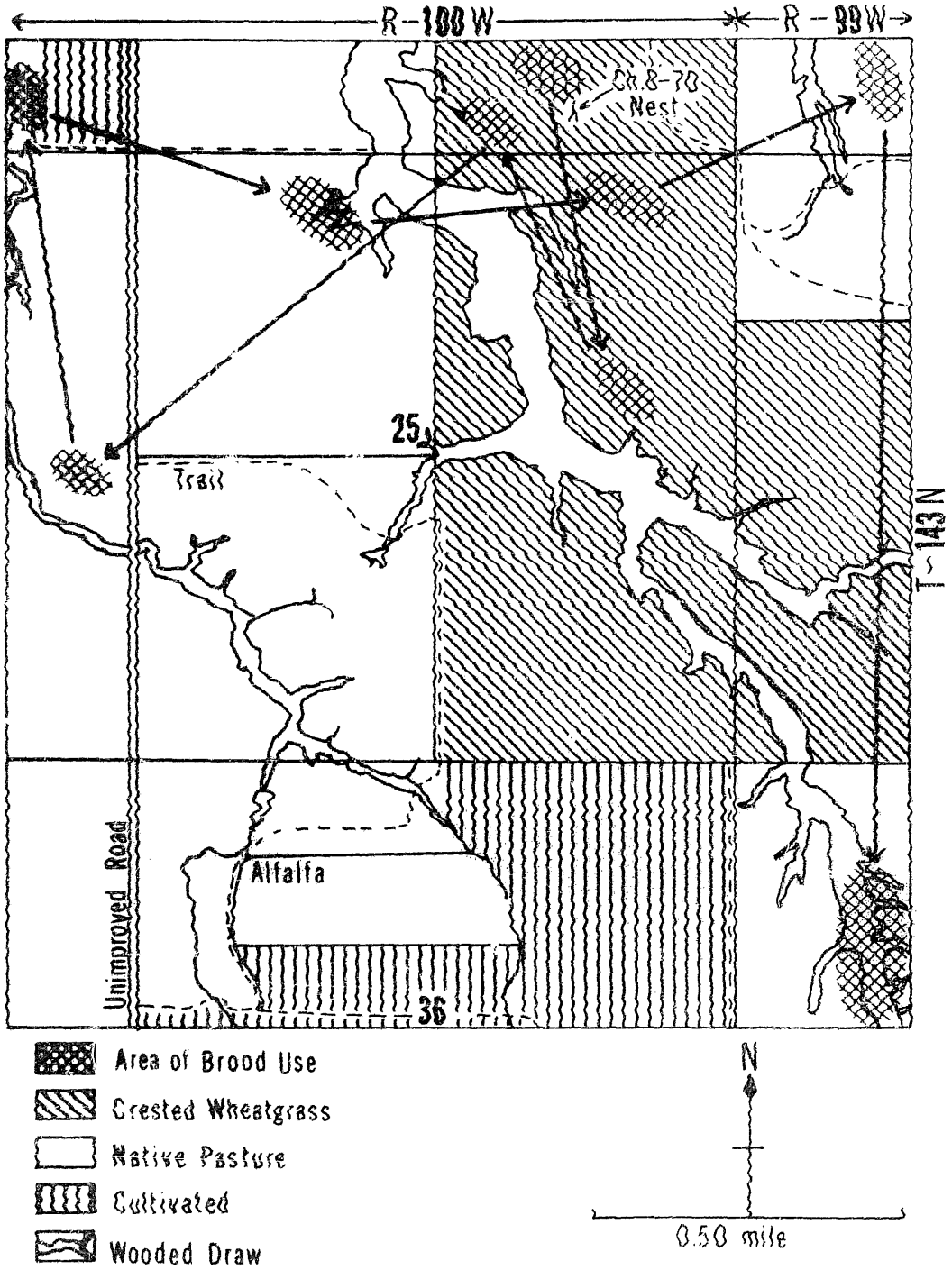

Fig. 9.--Channel 8-70 Brood Movement, Gorham Study Area, North Dakota, 1970

utilized. From July 11 until the hen was taken by a mammalian predator July 24 the brood remained 0.4 mi. north in the native hayland also used by channel 8-70 and utilized sweet clover as the primary cover (Figure 10).

Daily movements of these eight sharp-tail broods were generally within 1.0 mi. of their respective nest sites. Occasional daily movements of up to 1.0 mi. were noted in the study; broods less than a week old moved up to 0.8 mi. Table 17 summarizes the brood monitoring data, including home ranges.

Development of flight capacity at an early stage was observed in two broods. Broods of channel 6-70 and 8-70 were able to fly up to 30 yards at eight and nine days of age, respectively.

Three brood hens, channel 2-70, 8-70, and 10^{i}-70, were mointored continuously for two separate days to determine times of activities and cover used. A generalized summary of the daily activities of all broods observed in the study is presented in Figure 11. All broods had similar daily activity patterns, which began with intensive feeding immediately after sunrise in open areas. This was followed by a period of intermittent resting and feeding in increasingly dense cover. By mid-day the brood was resting in dense cover in draws. Subsequently, this was followed by intermittent feeding and resting in decreasingly dense cover which phases into an intense evening feeding period in light cover. Roosting was confined to upland sites in light cover. Wind,

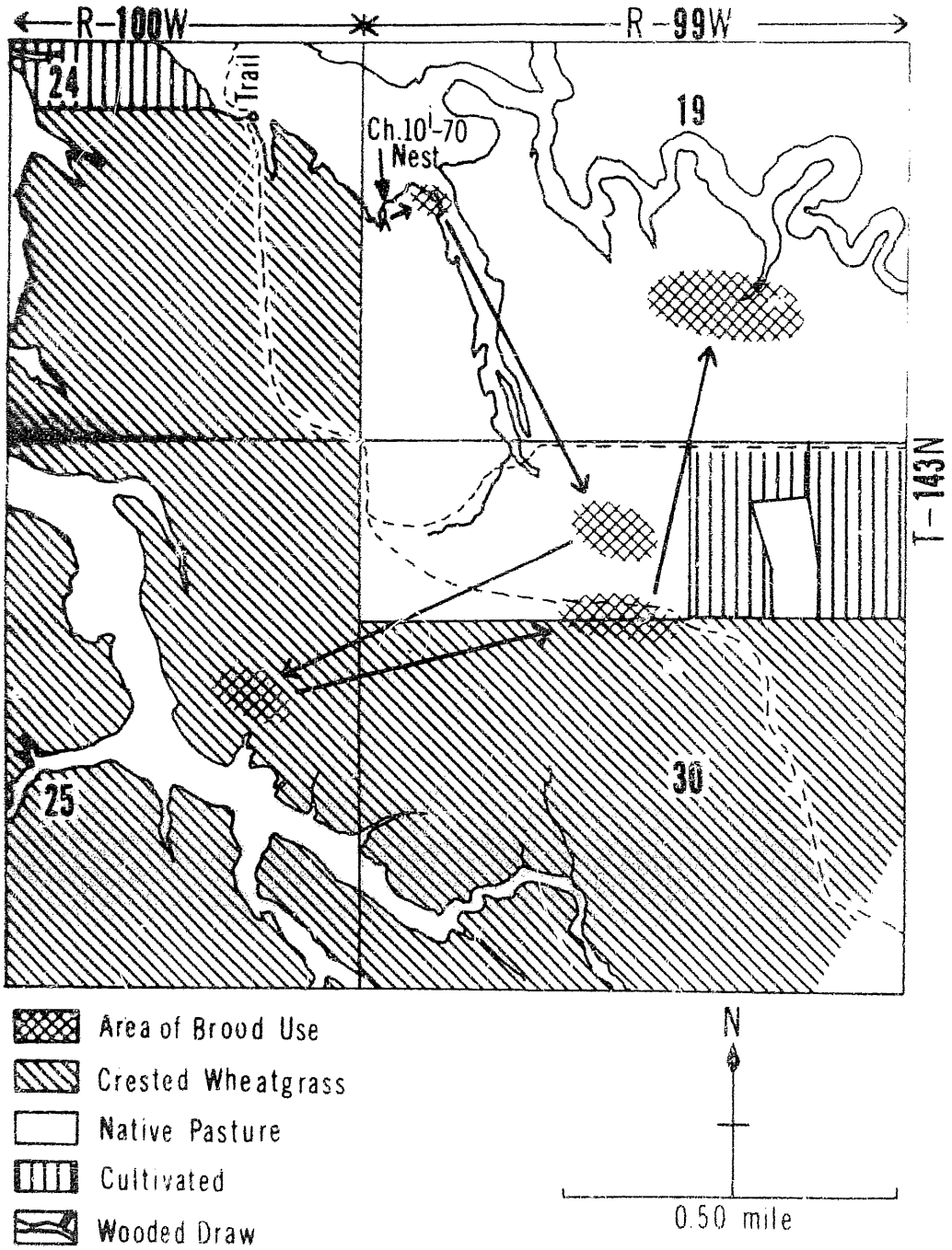

Fig. 10.--Channel 10^{i}-70 Brood Movement, Gorham Study Area, North Dakota, 1970

TABLE 17.--Home Range[a] and Daily Movements[b] of Eight Sharp-tailed Grouse Broods, Gorham Study Area, North Dakota, 1969-1970

	Broods							
Weeks	2-69	8-69	10-69	1-70	2-70	6-70	8-70	10[i]-70
	Acres							
1	50	80	0	60	20	50	45	50
2	120	-	20	50	40	60	100	40
3	-	-	40	80	60	120	110	35
4	-	-	100	40	60	-	130	45
5	-	-	-	-	80	-	120	-
6	-	-	-	-	120	-	60	-
7	-	-	-	-	120	-	70	-
8	-	-	-	-	60	-	-	-
9	-	-	-	-	70	-	-	-
	Miles							
1	0.4	0.4	0.1	0.4	0.3	0.8	0.4	0.6
2	0.5	-	0.1	0.4	0.3	0.5	1.0	0.6
3	-	-	0.4	0.4	0.4	0.3	0.4	0.4
4	-	-	0.4	0.7	0.2	-	1.0	0.2
5	-	-	-	-	0.4	-	0.8	-
6	-	-	-	-	0.3	-	0.3	-
7	-	-	-	-	0.5	-	0.4	-
8	-	-	-	-	0.2	-	-	-
9	-	-	-	-	0.2	-	-	-
Total acerage used	120	80	150	200	300	200	500	160

[a]In acres

[b]In miles

[i]Intermittent signal channel

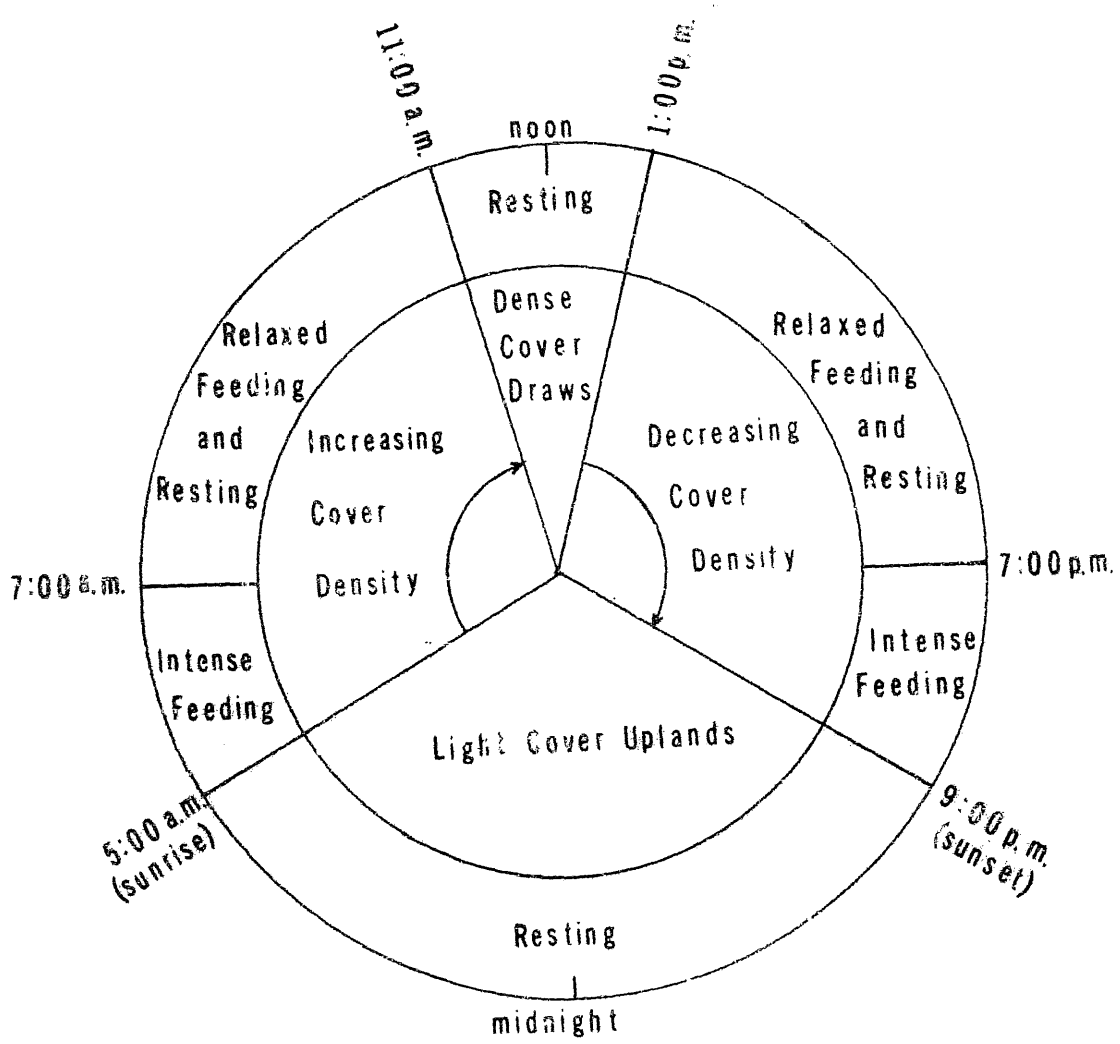

Fig. 11.--Daily Activities and Cover Selection of Sharp-tailed Grouse Broods, Gorham Study Area, North Dakota, 1969-1970

precipitation, and variations in daily temperatures affected the normal activities.

DISCUSSION

Trapping

Various techniques were used to recapture instrumented hens for battery replacement. One brooding hen was netted with a mobile cannon-net. Of 13 incubating hens recaptured on their nests, one was caught by hand, seven by hoop net, and five by bow-net trap. Bow-net problems include malfunction in dense vegetation and the interval required to allow the hen to return after flushing. The problems involved with hoop netting include the difficulty of approaching wary birds and netting them quickly and properly in order to prevent injury to the bird or nest. In an effort to create as little disturbance as possible at the nest site and to limit the number of trails into the nest, hoop net capture was attempted only once. If this was unsuccessful, the nest trap was used to assure that only one more disturbance would take place. With one exception, all captures were carried out towards the end of incubation to prevent desertion. One hen deserted after her non-functional transmitter was replaced early in incubation.

Active dancing had been observed on ground 5, a cultivated site, during the springs of 1966-1968. However, active dancing concentrations could not be located here in

1969 although small groupings of birds were occasionally seen. In 1970, a new ground was found one-half mi. to the west at a corner of a heavily grazed pasture. It was assumed that this was a relocation of ground 5 from the former cultivated site, because one male taken here had been previously banded at the cultivated site during the spring of 1967.

Telemetry

Telemetry equipment did not cause observable unusual behavioral effects, and normal nesting, incubating, and hatching or renesting took place. Previous studies have reported that instrumentation of game birds does not effect normal reproductive activity (Brown, 1965; Cebula, 1966; Kuck, 1966; Bernhoft, 1969).

Hen dispersal and nesting

One hen may have attended two different dancing grounds during the spring of 1969. Channel 3-69 had been trapped and released April 30 on dancing ground 4. She remained for 20 days in an area 1.4 mi. to the northeast, in the vicinity of a previously undetected dancing ground. On May 20 the hen moved 0.6 mi. further northeast to a brushy draw in which her nest was found May 30. Because the new dancing ground was not located until May 21, ch. 3-69's attendance on this ground was not determined; however, the hen was frequently found in association with other grouse from this dancing ground area.

During 1969, a year with average weather conditions, hen attendance at dancing grounds was approximately three

weeks. Thus, the nesting was extended; initial attempts were made throughout the period from April 25 through May 28. Therefore, in 1969 the period of nesting was considered to be of normal duration. In 1970, however, 26 inches of snow were recorded on the study area between April 10 and May 4. This apparently curtailed dancing ground activity which resulted in a short peak of attendance by hens and a subsequent concentration of all but one of eight initial nesting attempts into one four day period between May 12 and May 16. Predation may have extended the period in which nesting was attempted and thus reduced the possibility that all nests and broods would be eliminated by the same general disaster. This is in accord with the findings of Cartwright (1944) and Symington and Harper (1957) that predation may be a mechanism which operates in prolonging the period when nesting is attempted

Hamerstrom (1939), Cartwright (1944), Ammann (1957), and Blus and Walker (1966) reported that the reproductive success of prairie grouse depends upon initial nesting efforts because they do not persistantly renest, however, considerable renesting was observed in the present study. Seven of nine birds whose nests were destroyed by predators, renested. The two other birds apparently did not renest, however their nests were found in early June and may have been the product of renesting.

Renesting was more successful than initial nesting. Four of six renests (not including a desertion caused by early

transmitter replacement) hatched while only 7 of 17 initial nests hatched. As the season progressed the amount of available nesting cover vastly increased. Therefore, if the numbers of predators in the area remained constant, the additional cover probably increased renesting success.

Vegetation at nest sites

Of 25 nest sites (including ch. 10-70's nest bowl), ten were associated with crested wheatgrass, five with buckbrush, three with buffalo berry, two with sweet clover, two with quackgrass, and one each with smooth brome alfalfa, and green needle[illegible]. The only comparable characteristic found at all sites was the height of the cover. Vegetation at all sites, other than those associated with buckbrush and buffalo berry was at least 12 inches tall over a unifor area. Nest sites associated with buckbrush and buffalo berry were at locations along edges where the height of the vegetation was from 14 to 70 inches. Therefore, it would seem that sharp-tail hens require uniform vegetation not less than 12 inches or patchy vegetation not less than 14 inches in height for nesting. The predominance of heavily grazed pasture on the Gorham Study Area where the height of vegetation was considerably less than a uniform 12 inches may have forced many hens to seek taller patchy vegetation for nesting sites. In most cases these were brushy draws which are definite predator lanes. This was reflected in the destruction of 5 of 7 nests located in brushy draws. In addition, only 2 of 11 clutches which were successfully hatched were from nests located near these draws.

Crested wheatgrass was the dominant species present at both initial and renest sites. This may indicate that this was preferred nesting cover because sharp-tails tend to locate nests in crested wheatgrass. On the other hand wheatgrass may be ideal initial nesting cover because it overwinters well and, thus, provides residual cover. Residual vegetation comprised between 10 to 90 per cent of nesting cover at initial nests. In addition, six of eight nests associated with crested wheatgrass hatched. Conversely buckbrush and buffalo berry may be considered as less preferred nesting cover and of questionable value. Although 8 of 25 nests were associated with buckbrush and/or buffalo berry only two hatched.

Predation

Predation apparently plays an important role in limiting sharp-tail reproduction. Twelve of 24 nests located in the study were lost to predation. The average length of time between the last visual observation of the nest and predation was approximately eight days with a range from 3 to 15 days; hens were monitored daily. In many cases a rain shower or thunderstorm intervened between this observation and predation. It seems unlikely that predators could trail the investigator to the nest sites under such conditions, however, Brown (1966b) found that increased nesting hen predation by coyotes was apparently caused by trailing. In two, possibly three, of the 12 nest predations the hen was taken. This was between ten and twenty per cent of the 17 instrumented hens.

Brooding hens are apparently more susceptible to predation than non-brooding hens. Four of eight hens with broods were taken by predators, while only one of five non-brooding hens was preyed upon. This may be due to the fact that brooding hens tend to hold tighter when approached and can be readily taken by the predator.

Brood movement and cover selection

Of 11 hatching broods only portions of two (three young) were with the hens at the termination of the study in late August. Severe weather apparently caused the loss of three broods. Channel 2-69's chicks were only 11 days old when a cold three day rain occurred; they were never again seen. Channel 6-69 and 12-70 were in the process of hatching during severe thunderstorms with high winds, heavy rain, and a large amount of small hail. Both nests were observed within 12 hours after the storms. A few hatched young had been washed down the slope and the remainder of the broods had only partially emerged from the shells. Haying operations resulted in the loss of one brood, channel 8-69's, which was located in an alfalfa field at the time it was being windrowed. The hen was flushed from the field and one of eight chicks was found alive in a windrow; the hen was never seen with the brood again. One brood died in the early morning cold on the day following hatching during a prolonged attempt to capture the hen. The hen of the other four broods (28 young) were lost to predation (two mammalian and two avian). It was not determined if any or

all of these young lived until the study ended although the broods ranged from 16 to 47 days of age at the time of predation and most were increasingly independent of the hens.

Young broods less than two weeks old apparently were dependent only on the hens for shelter as they generally moved to and remained in closely grazed pastures of short sparce vegetation. Subsequently, there was an increasing dependence on more dense cover because the broods moved to areas which furnished available protective cover, usually brushy or wooded draws.

The daily movements and ranges varied throughout the study but a general pattern was followed by most broods. At an early age the broods moved relatively short distances and had small ranges; at three to four weeks of age brood movements and ranges reached maximums. Although only two broods were monitored at ages greater than five weeks, both localized in close proximity to draws and, therefore, had reduced daily movements and ranges.

RECOMMENDATIONS

If the activities of this small group of radio-equipped hens are indicative of the true situation, then one form of improved land management can be suggested; this would also be effective grouse management. Sharp-tail populations might be substantially increased by regulating grazing to provide uniform areas with 12 inch high vegetation for nesting cover. This can be provided either by establishing small exclosures in heavily grazed areas or by regulating grazing rotation so that it will provide suitable spring nesting habitat each year.

The following recommendations are suggested:

(1) Continue the investigation to determine whether an individual female attends more than one dancing ground and to investigate the possible effect this will have on the location of the initial and subsequent nesting.

(2) Examine the allotment records of the last five years, for all public lands included in the study area, to determine if there is a correlation between grazing pressure and a concentration of grouse nesting.

(3) Examine existing cattle exclosures in grouse habitat in southwestern North Dakota to determine

whether increased nesting activity and greater hatching success are realized on such areas.

(4) Establish cattle exclosures to determine whether they will enhance sharp-tail nesting on the study area. This data could be readily compared with data concerning nesting which has been collected over a period of four years.

(5) Determine the condition and trend of the vegetation and soil of the area in the vicinity of all nest sites by utilizing paced line transects.

(6) Determine the time the female spends on the nest in laying and incubating the clutch and monitor temperature and humidity in sharp-tail nests with battery operated timing devices and hygrothermographs.

(7) Record the density of vegetation, the precise time of day and the temperature at each brood location to determine whether there is a correlation between these factors.

(8) Secure the addition of a full time assistant, for approximately 50 man-days, in order to monitor a greater number of instrumented females, to recapture females for battery replacement, and to assist in searching for and capturing non-instrumented brooding hens. In addition a collateral study of predation and prey availability could be initiated

to determine whether there is a correlation between the availability of small mammals and nest predation pressure.

(9) Consider the possibility of placing poisoned sharp-tail or pheasant eggs in each nest to determine the specific mammalian predators involved in nest predation.

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